No. 369

In the Supreme Court of the United States

October Term, 1942

Marconi Wireless Telegraph Company of America, petitioner

v.

The United States

ON WRIT OF CERTIORARI TO THE COURT OF CLAIMS

BRIEF FOR THE UNITED STATES

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Argument—Continued.

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OPINIONS BELOW

The opinion of the Court of Claims on the issues of validity and infringement of the patents in suit (I R. 7–116[1]) is reported at 81 C. Cls. 671; its opinion on the accounting proceedings (I R. 117–182) is not yet officially reported.

JURISDICTION

The interlocutory judgment of the Court of Claims concerning validity and infringement, pur-

[1] The record citations refer to the volume and page.

suant to which an accounting was held, was rendered November 4, 1935 (I R. 75); the final judgment after the accounting proceedings was rendered April 6, 1942 (I R. 182). The petition for a writ of certiorari was filed on September 2, 1942 (III R. 2524), pursuant to an extension of time granted by the Chief Justice (III R. 2523), and was granted on December 14, 1942. The jurisdiction of this Court is invoked under Section 3 (b) of the Act of February 13, 1925, as amended.

QUESTIONS PRESENTED

I. Whether the Court of Claims erred in holding the Marconi patent No. 763,772 invalid as to all the claims in suit other than claim 16.

II. If the answer to the first question is in the affirmative, whether the Marconi patent was infringed by defendant's apparatus.

III. Whether the Court of Claims erred in holding that claims 1 and 37 of the Fleming patent No. 803,684 were not infringed by the United States.

IV. If the answer to the third question is in the affirmative, whether the Fleming patent was invalid for—

(1) anticipation by the prior art;

(2) unreasonable delay in disclaiming a part of the patent lacking invention; or

(3) impropriety of the subject matter of the disclaimer.

STATUTES INVOLVED

The Appendix, pp. 175–178, *infra*, contains the pertinent provisions of the statutes involved.

STATEMENT

On July 29, 1916, petitioner Marconi Wireless Telegraph Company of America (herein called "plaintiff") brought this suit in the Court of Claims under the Act of June 25, 1910, to recover compensation for the allegedly unauthorized use by the United States (herein sometimes called "defendant") of inventions alleged to have been covered by four United States patents, two issued to Guglielmo Marconi, one to Sir Oliver Lodge, and one to Sir John Ambrose Fleming.

The court below held that one Marconi patent, reissue No. 11,913, was not infringed (I R. 117), and that the Lodge patent No. 609,154 was valid and infringed (I R. 117). As to these, no review has been sought by either party.[2] The court below further held that claim 16 of Marconi patent No. 763,772 was valid and infringed (I R. 117), and after accounting proceedings rendered final judgment on April 6, 1942, awarding plaintiff compensation in the amount of $42,984.93 plus interest (I R. 182). The decision concerning claim 16 is now before this Court in *The United States* v.

[2] The final judgment rendered after the accounting proceedings awarded plaintiff $34,827.70 plus interest for infringement of the Lodge patent (I R. 182).

Marconi Wireless Telegraph Company of America, No. 373, this Term.

The remaining claims in suit of Marconi patent No. 763,772[1] were held invalid (I R. 117), and the Fleming patent No. 803,684 was held not infringed (I R. 117). This decision is the subject of the present proceeding.

The findings of fact of the court below, briefly summarized, were:

Marconi Patent No. 763,772 granted on June 28, 1904, was directed to the tuning of wireless telegraph transmitters and receivers, and claimed an improvement therein. The preexisting transmitter alleged to have been improved by Marconi consisted of a charging circuit and an antenna circuit. The charging circuit of the preexisting transmitter, which generated the oscillations, contained means for producing high frequency electrical oscillations, namely, a spark coil, a charging condenser and a spark gap. The antenna circuit, which transmitted the oscillations, had an antenna at one end and a connection to earth at the other. The charging circuit and the antenna circuit were coupled together by a transformer (Finding XLIII; I R. 38.)

The preexisting receiver alleged to have been improved by Marconi likewise consisted of two circuits: an antenna circuit and a detector circuit. The antenna circuit, which received the

[1] Claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 17, 18, 19, and 20.

oscillations, had an antenna at one end and a connection to earth at the other. The detector circuit contained a means for detecting the transmitted oscillations (such as a coherer) and a means for translating them (such as a telegraph sounder). The detector circuit and the antenna circuit were coupled together by a transformer (Finding XXVII; I R. 24).

The alleged improvement of the Marconi patent (as embodied in all claims involved in suit except claim 16) consisted in adjusting the inductance and capacity of either the two circuits at the transmitter or the two circuits at the receiver, or all four of these circuits, in order to tune or bring them into resonance to the same frequency or wave length (Findings XXXVIII–XLIII; I R. 31–38).

The court below found that this alleged improvement was anticipated and consequently invalidated by the prior art (Findings LVII–LIX, LXI, LXII; I R. 56–60). It made findings as to the subject matter of the prior art and of the claims in suit, showing, by direct comparison, the lack of novelty in the latter (Findings XXVII, XL–XLIII, LI–LIX, LXI–LXII; I R. 23, 32–40, 45–57, 57–59). More specifically, it found or held that all claims for four-circuit tuning (except claim 16, which was sustained on account of a feature not relevant here) were anticipated by Stone patent No. 714,756 (Finding

LVIII; I R. 57), and by Tesla patent No. 645,576 read in conjunction with Lodge patent No. 609,154 (I R. 98).*

Fleming Patent No. 803,684 granted on November 7, 1905 (claims 1 and 37 in suit), disclosed a radio receiving circuit using as a rectifying detector the two-electrode tube of Edison patent No. 307,031 (Findings LXIV, LXX, LXXI; I R. 60, 64–67). The unilateral conductivity of the Edison tube and its ability to rectify (by changing to direct current) alternating currents when connected in a detector circuit as defined in claim 1 of the Fleming patent had been described in publications as early as 1890, fifteen years before Fleming filed his patent application; and it was such rectification, with the same detector circuit, that claim 1 of the Fleming patent described (Finding LXXI; I R. 67). In 1915, ten years after the patent issued, plaintiff as Fleming's assignee filed a disclaimer purport-

* The Marconi claims for effecting four-circuit tuning by means of a variable inductance were also found to have been anticipated by the Lodge patent, and six Marconi claims were found to be additionally anticipated in other prior art, as follows (Findings LIX and LXI; I R. 57):

Marconi Patent No. 763,772	*Anticipating Prior Art*
Claims 2, 13, 18, 19.	Marconi Patent No. 627,650.
Claims 1, 3.	Lodge Patent No. 609,154, Fig. 4.
Claim 2.	Lodge Patent No. 609,154, Figs. 12, 13.

ing to limit the field of use of certain claims (including claim 1) to the use of the two-electrode rectifier, without change, to rectify alternating currents of high (or Hertzian wave) frequencies (Finding LXXII; 1 R. 67). The Edison two-electrode rectifier used by Fleming consisted of two elements within a vacuous enclosure: a filament heated to cause it to emit electrons, and a colder plate in proximity to but not touching the filament. The two elements were connected by a circuit outside the tube, and, because the electrons flowed through the tube only from the hotter to the colder element, alternating current introduced into the circuit from an external source would pass in only this one direction through the vacuous space between the elements, thus resulting in rectification.

The alleged infringements by the defendant consist of the use of the three-electrode vacuum tubes of DeForest, and the purchase of such tubes and apparatus for use in receivers and transmitters (Finding LXXV; 1 R. 69). The defendant's receivers used the DeForest three-electrode vacuum tubes as detectors and amplifiers. In these arrangements, the vacuum tube contained not only the two electrodes of the Edison tube, but also contained a third element—a grid of spaced wires—placed in the vacuous space in the tube between the hot filament and the plate. The heated filament and plate of the tube were

here connected with a *direct current* battery circuit, having its negative end permanently connected to the filament and its positive end permanently connected to the plate, and thus tending to produce a flow of current through the tube at all times. The operation of the device depended on the discovery that by changing the potential of the grid, the flow of electrons from the always negatively charged filament (cathode) to the always positively charged plate (anode) could be controlled. In the detector arrangement, the translating device (the headphone) was placed in the local battery circuit, and the incoming alternating current signal was connected through a grid condenser to the grid in the tube, so that the audio-components of the received oscillations would so polarize the grid relative to the filament as alternately to retard and accelerate the flow of the larger battery current between filament and plate (Finding LXXV; I R. 69). In the amplifier arrangement, an alternating current of audio-frequency was applied to the grid to control the increase or decrease of a larger current in the battery circuit (Finding LXXVI; I R. 72).

The court below found that insofar as defendant's structures and the invention disclosed in the Fleming patent had anything in common, the common matter had been disclosed in the earlier Edison patent and was well known to the art

before the earliest date to be accorded the Fleming patent; that the art was familiar with the ability of the Edison tube to rectify alternating currents; that the Fleming patent, to one skilled in the art, included only the use of the well-known "Edison effect" to rectify alternating currents of radio frequencies; that the defendant's manner of using the "Edison effect" differed in means for applying it, mode of operation, and result, from that of Fleming (Findings LXV–LXXX; I R. 62–74); and that defendant's structures therefore did not infringe the Fleming patent (Finding 1; I R. 116–117).[5]

Although the ultimate findings of fact on which the judgment relating to the Fleming patent is based (I R. 60–74) were restricted to the issue of infringement (I R. 75), and did not include matters relating to validity, the court made evidentiary findings relating to the prior art and to the disclaimer; and in its opinion the court below held that the Fleming patent was invalid because of unreasonable delay in filing the disclaimer (I R. 105–107).[6] The court further indicated, without

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[5] Findings identified by arabic numerals refer to those made by the court below after the accounting proceedings, in connection with the final judgment of April 6, 1942; roman numerals refer to findings made before such proceedings, in connection with the interlocutory judgment of November 4, 1935.

[6] The court found that the disclaimer was filed long after the three-electrode tube had been invented and employed in radio apparatus as a detector, amplifier and oscillator, and

deciding, that the patent may also be invalid because the alleged new use Fleming made of the "Edison effect" lacked invention (I R. 104–105).

SUMMARY OF ARGUMENT

I

The court below properly held that the Marconi patent No. 763,772, as to all claims in suit except claim 16, was invalid because anticipated in the prior art. The alleged improvement in the field of wireless communication, which the patent purported to disclose as of November 10, 1900, consisted in adjusting the inductance and capacity of either the two circuits at the transmitter or the two circuits at the receiver, or all four of these circuits, in order to tune them to the same frequency or wave length. All these features had already been shown in the art, as the court below properly found. Hertz between 1879 and 1890 had established the basic principles of tuning the transmitting and receiving circuits of a wireless system to the same frequency in order to sustain the maximum response. Lodge in 1894 fully explained Hertz' teachings in terms of a wireless communication system, and Marconi in an 1897 patent showed receiving apparatus which could be electrically tuned to oscillations from a transmitter.

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after the United States had used substantial quantities of three-electrode tubes as detectors and amplifiers (Findings LXV, LXXI; I R. 62, 74).

Then Tesla in 1897 showed (as Marconi's patent in suit showed in 1900) a wireless transmitter system containing a charging circuit for causing oscillations of a desired frequency, an antenna circuit for transmitting these oscillations, coupled to the charging circuit through a transformer, and the synchronizing or tuning of these two circuits by adjusting the inductance of the circuits. Tesla, moreover, disclosed the same arrangement in the receiver, and thus anticipated the four circuit tuning combination of Marconi.

The only feature in Marconi's arrangement which was absent from Tesla's was the use of a more readily variable inductance in the antenna circuit as the tuning medium of the transmitter, but this very feature, used for the same purpose, was found in Lodge's disclosure of 1898, almost three years prior to Marconi. Hence, the court below properly held that Tesla, read in conjunction with Lodge, anticipated all of Marconi's claims for four-circuit tuning. It might properly have found that Lodge alone anticipated all the receiver claims. Similarly, the 1899 patent of Marconi, antedating the one in suit, brought out the principle of tuning the circuits of transmitter and receiver by variable inductance coils, in accordance with the varying wave lengths. Finally, before Marconi's date of November 10, 1900, Stone disclosed on February 8, 1900 (and even earlier in his letters to Baker) the

tuning of all four of the open and closed circuits of transmitter and receiver to the same frequency. While Stone did not prescribe the particular means for adjusting the frequency of the aerials, he did prescribe tuning them to the desired fundamental frequency; and the art was familiar at that time with the use of a variable inductance for such purpose.

Prior litigation upholding the Marconi patent is of no authority on the question of validity since in two of the cases the Stone defense was not before the court and in the third the patent was held not infringed, rendering unnecessary any opinion as to invalidity. Moreover, none of the prior cases considered specifically whether there was any invention in using the Lodge tuning coil to effect the tuning of Tesla's apparatus.

II

An additional ground for affirmance of the judgment for defendant, urged but not passed on below, is that the evidentiary findings made by the court and the record upon which they are based establish that defendant's apparatus did not infringe the Marconi patent. No criteria of infringement are available under the decision below since all claims of the Marconi patent (except claim 16, not here involved) were held invalid. But the conclusion must be against infringement even if, as the criteria, there be taken

features judicially upheld in two decisions of lower federal courts (*Marconi Wireless Telegraph Co.* v. *National Electric Signaling Co.*, 213 Fed. 815 (E. D. N. Y.) and *Same* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328 (W. D. Wash.) affirmed 265 Fed. 644 (C. C. A. 9)), and in a decision of an English court concerning the corresponding British patent (*Marconi* v. *British Radio Telegraph & Telephone Co.*, 27 T. L. R. 274). The feature held novel in these cases was the use in the transmitter of a persistently oscillating charging circuit employing a low resistance plain spark gap, with loose coupling between that circuit and an antenna circuit in exact tune therewith. With this arrangement the charging circuit fed only a small part of its energy to the antenna circuit on each oscillation, so that the radiation of the antenna circuit would be continually replenished on each oscillation and thus be prolonged. The courts in question distinguished this arrangement from the prior art transmitter of the Lodge patent, which used tight coupling and a more highly resistant, and less persistent oscillator circuit, whereby the latter would deliver its energy to the antenna in a rush and then cease operating, to leave the antenna circuit free to oscillate at its own natural period and rate of damping.

The defendant's quenched gap transmitters, constituting most of the transmitter apparatus

alleged to infringe, do not employ the distinctive structure, mode of operation, and result held to differentiate Marconi's system from Lodge, but instead follow Lodge's principles, using a high-resistance quenched gap in a charging circuit tightly coupled to a somewhat detuned antenna circuit—features which prevent the charging circuit from being a persistent oscillator, and give both the charging and antenna circuit a mode of operation like that of Lodge and different from that of Marconi's arrangement. The commercial displacement of the plain gap transmitters by the quenched gap type soon after their development further attest to their substantial dissimilarity. On principle and authority and in view of the prior art, these transmitters did not infringe Marconi's alleged invention.

Defendant's rotary gap transmitters were similar to the quenched gap type, also quenching the spark quickly and preventing the charging circuit from being a persistent oscillator; these transmitters did not infringe for the reasons stated with respect to the quenched gap transmitters. And the few plain gap transmitters used by the defendant did not trespass upon Marconi's patent because defendant's apparatus had direct instead of transformer coupling between the charging and antenna circuits, and there is no evidence that they were loosely coupled or that they attained Marconi's slow feeding operation and result.

Defendant's receivers also do not infringe the Marconi patent. The features of Marconi's system upheld by the three courts referred to above were attributable solely to Marconi's transmitter, and not to his receivers, *per se;* and to the extent that any matters disclosed by Marconi are to be found in defendant's receivers, they are equally to be found in the prior art.

III

The court below properly found that the Fleming patent No. 803,684 was not infringed, and did not pass upon the defense of invalidity urged by defendant. However, the court's evidentiary findings as to the prior art, and as to the structure, operation, and effect of Fleming's device—which were required in order to enunciate the proper criteria for gauging the alleged infringement—necessarily lead to a conclusion of invalidity.[6] The Fleming patent disclosed a two-electrode vacuum tube, one electrode of which was heated, with a circuit connecting the two electrodes outside the tube. A direct current indicator in this circuit responded when an alternating current was impressed on the circuit and rectified by the one-way conductivity of the tube. The incoming alternating current signal was received in an antenna circuit and was impressed on the single external circuit of the tube by a transformer.

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[6] As to the order of argument, see n. 49, p. 105, *infra.*

Every element of this arrangement, and this combination, was to be found in the prior art. Edison in 1884 received a patent on the very two-element tube shown by Fleming as of November 16, 1904, containing a heated filament and a colder plate, connected together outside the tube. The rectifying operation of the Edison tube upon alternating currents, due to the unidirectional flow of current between filament and plate, was recognized and published by Fleming in 1890, more than ten years before his patent application; it was also described and illustrated by others in 1897. In 1903, the deValbreuze patent employed a similar two-electrode tube in an identical circuit to rectify alternating currents of high or Hertzian wave frequency, and Wehnelt in October 1904—a month before Fleming's earliest date—also disclosed the specific arrangement described in Fleming's patent to rectify alternating currents. The art prior to Fleming, in discussing the rectifying operation of the Edison tube, properly had drawn no distinction between rectifying high frequency and low frequency alternating currents; and to those skilled in the art it was implicit in the known operation of the device, that it would rectify low or high (Hertzian) frequencies of alternating current with equal facility. The specific disclosure of the prior art de Valbreuze patent applying a like two-electrode tube as a rectifying

detector of wireless waves, in the same circuit proposed by Fleming, disposes of any contrary contention. The Fleming patent was thus invalid for anticipation and lack of invention.

Additional reasons exist for invalidity of the Fleming patent. Plaintiff disclaimed from the scope of that patent all use of the device to rectify low-frequency currents, but did so more than ten years after it had been held out to the public as dominating rectification of high and low frequencies. Indeed, whatever the frequencies, the arrangement operated without change in but one manner, to produce but one result, rectification. The patent when issued, on its face squarely covered subject matter which Fleming knew had entered the public domain years before. The disclaimer thus was unreasonably delayed. Moreover, the subject matter of the disclaimer was improper, for it either did not disclaim any properly separable part of the patent, or it attempted to add a new element to the invalid claims—the requirement that the current rectified be of radio frequency.

IV

The finding of the court below that the Fleming patent No. 803,684 was not infringed by the DeForest three-electrode tube employed by defendant, is sustained by evidentiary findings which are in turn supported by substantial evidence. The Fleming patent employed the Edison two-electrode

tube as a rectifier of alternating current introduced into its single external circuit to enable that very current, when rectified, to operate an indicator in that circuit. DeForest's three-electrode tube, on the contrary, employed only the large direct current of a local battery in its plate circuit to operate the indicator. This current needed no rectification. DeForest added a new discovery to the Edison tube, nowhere suggested by Fleming, namely, that by placing a third element, a grid, in the evacuated space between the filament and plate, it would be possible to impart to the tube a new mode of operation, relay action, enabling one to produce large changes in the local battery current of the plate circuit by impressing small potential changes on the grid.

As the incoming energy acted in the grid circuit to control a local current in the entirely separate plate circuit, the device was a relay. As it produced disproportionately large changes in the current of the plate circuit, compared to the changes of potential on the grid, the device was an amplifier. Thus its structure, mode of operation and result were different from those of the Fleming device.

Further, the three-electrode tube served to reproduce, as variations in the local plate current, changes of potential, however derived, applied to the grid. In defendant's amplifiers, the changes of potential were derived from an alternating

current of low or audio-frequency (excluded from the Fleming patent by disclaimer). In one form of defendant's detector, the grid was given a basic negative charge by a small battery in the grid circuit so that it would permit only a small current to flow in the plate circuit. Alternating current applied to the grid then rendered it alternately more positive and negative than its basic charge, reproducing by relay action the modulation of the incoming alternating current by allowing large increases and causing only small decreases in the plate current. These plate current variations, when averaged up by an indicator, caused the indicator to respond to the reproduced modulation. In the other form of detector, a grid condenser bridged by a high resistance leak was employed in lieu of the grid-biasing battery. This arrangement caused the grid to assume a negative charge proportional to the modulation (amplitude) of the incoming signal and thus, by relay action, to reproduce, in variation of the local direct current in the plate circuit, a replica of the intelligence transmitting characteristic of the signal, suitable to operate the indicator.

The ability of the three-electrode tube to amplify enables it to be used as an oscillator or self-sustained generator of oscillations for use in a transmitter; and plaintiff now concedes that the two-electrode valve, as disclosed by Fleming, cannot either amplify or oscillate. Oscillation in

the triode is effected by using a little of the current variation in the plate circuit to effect changes in potential of the grid which in turn produce larger variations in the plate current, until a maximum variation of plate current results; and this continues as a steady oscillation continuously replenished by amplification through the tube. That portion of the steady oscillation not being "fed-back" to maintain the tube in oscillation may then be delivered to a transmitting antenna circuit coupled directly, or through a transformer, to the plate circuit of the oscillating tube circuit, for radiation thereby. The regenerative receivers employed the same "feed-back" principle, but fed-back only enough energy to reenforce an incoming signal applied to the grid, and not enough to sustain the tube in oscillation.

Thus the Fleming patent used the two element tube theretofore shown by Edison, in an already known alternating current rectifying circuit containing a direct current indicator, to *rectify* the received alternating currents of Hertzian frequencies, so that the rectified energy of those received currents could operate the direct-current indicator in the alternating-current circuit. Defendant's three-electrode tubes employed a different structure (a three-element tube) operating in a different way (by relay action) to produce a different result (an amplified reproduction in a large local direct current of a replica of voltage variations impressed on the grid).

The substantial dissimilarity between defendant's and Fleming's devices is further shown by the rapidity with which the triode replaced the older form of tube, and the signal contributions which the triode made to the art. The only case which held the Fleming patent valid and infringed by DeForest's triode is *Marconi Wireless Telegraph Co. of America v. DeForest Radio Telephone & Telegraph Co.*, 236 Fed. 942 (E. D. N. Y.), affirmed 243 Fed. 551 (C. C. A. 2). That decision is entitled to little weight on either of these issues, for both parties had there agreed, for collateral reasons, that the two-electrode and three-electrode vacuum tubes were essentially alike, thus eliminating any controversy on the matter crucial to the decision here.

ARGUMENT

The judgment entered below holding Marconi patent No. 763,772 invalid and Fleming patent No. 803,684 not infringed can be challenged only by showing that the findings of fact lack substantial evidence to support them or that the ultimate findings of fact are not sustained by the evidentiary findings of fact. We believe that plaintiff has not and cannot make any such showing. But even if the court below were in error in holding the Marconi patent invalid and the Fleming patent not infringed, we submit that the judgment should be affirmed because it is adequately sustained by additional grounds, which were urged

but not passed on by the court below. More particularly, we submit that the Marconi patent, even if valid, was not infringed by the defendant's transmitters because these differed substantially from Marconi's arrangement in structure, mode of operation and result. Likewise, the Fleming patent, whether or not infringed, was in our view invalid because anticipated, at least as to the features alleged to have been infringed, by prior disclosures. In any event, Fleming's patent was invalid because the 1915 disclaimer of the device as applied to low frequency currents was made after unreasonable delay and was not in its substance within the disclaimer statutes. The evidentiary findings made below will sustain the judgment in defendant's favor upon these alternative grounds; and such alternative grounds, having been urged below, may be considered by this Court. *Stelos Co. v. Hosiery Motor-Mend Corp.*, 295 U. S. 237.

PART ONE: MARCONI PATENT NO. 763,772

Point I

THE COURT BELOW PROPERLY HELD MARCONI PATENT NO. 763,772 INVALID BECAUSE ANTICIPATED IN THE PRIOR ART

The court below found that Marconi patent No. 763,772, as to all claims in suit except claim 16, was anticipated by the prior disclosures of Tesla, Lodge and Stone, and by an earlier patent to Mar-

coni himself. This conclusion is supported by adequate evidentiary findings of fact, which are in turn grounded upon substantial evidence.

1. *The Disclosures of Marconi Patent No. 763,772*

Marconi patent No. 763,772 was granted on June 28, 1904. Its stated object was "to increase the efficiency" of wireless telegraph transmitting and receiving systems, and

> to provide new and simple means whereby oscillations or electric waves from a transmitting station may be localized when desired at any one selected receiving station or stations out of a group of several receiving stations (Ex. 21, p. 1, lines 13–19; IV R. 2588).

The means employed by Marconi to carry out his invention are illustrated as follows in Figures 1 and 2 of his patent:

(a) The Transmitter: Claims 1, 3, 6, 8, 11, and 12

At the transmitting station (Fig. 1), the patent specification (IV R. 2591) calls for

(i) an oscillation transformer *d d'* "of a kind suitable for the transformation of very rapidly alternating currents" (lines 36–38),

(ii) "one coil of said transformer" *d'* "being connected between the aerial wire or plate" *f* "and the connection thereof to earth" *E*.

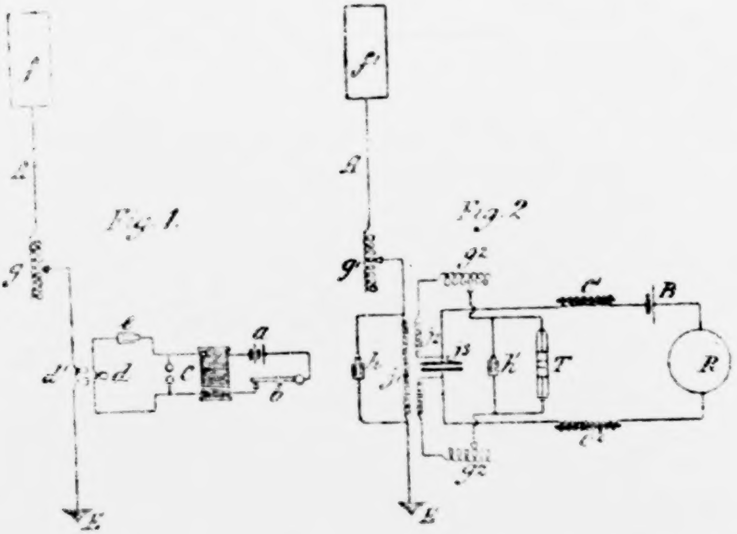

Fig. 1. Fig. 2.

(iii) "while the other coil of the transformer" *d* "is connected in circuit with a condenser" *c* (lines 39–43), and forms part of

(iv) a persistent oscillator, which further comprises "a producer of Hertzian oscillations or electric waves shown in the form of a spark producer" (i. e., the low-resistance plain spark gap, adjacent to the letter *c*) "and an induction coil (*c*) controlled by a signaling instrument" *b* (lines 43–46), and

(v) a good radiator (i. e., the open antenna circuit, *f A E*).

The specification explains that the battery *a*, through the induction coil *c*, charges the condenser *c* until the voltage thereof is sufficiently high to break down the resistance of the spark gap (adjacent to the letter *c*), whereupon the current leaps the gap and completes the primary

circuit, *c d* and gap, creating high frequency oscillations therein. This circuit, sometimes referred to as the charging circuit, constitutes the "persistent oscillator" of the patent.[7] The spark gap is shown as a "plain gap", i. e., one of relatively low resistance which allows the oscillations to persist in the charging circuit, *c d* and gap, for some time before being damped out by the resistance of the circuit. The circuit is tuned to the desired frequency of transmission by the inductance (the coil *d*) and capacity (the condenser *c*) in the circuit; hence, the oscillations in the charging circuit will persist for a maximum period of time commensurate with their transfer to the antenna circuit before the spark gap ceases to be conductive. As long as the oscillations persist in the charging circuit they will induce correspondingly prolonged oscillations in the antenna *A* to which the charging circuit is coupled by the oscillation transformer *d d'*. The persistency of the oscillations is aided, and their

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[7] The patent specification states (IV R. 2592, lines 12–24): "My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit, and use a good radiator—i. e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit."

gradual transfer from the charging circuit to the antenna or radiating circuit is effectuated. by "loosely" coupling the circuits so that only a small portion of the energy of each oscillation in the charging circuit is transferred to the antenna circuit on each alternation of the current. This "loose-coupling" is effectuated by the presence in the antenna circuit of the relatively large inductance g, which, not being coupled to the charging circuit, acts to delay (i. e., "swamp" or "bog down") the influx of energy from the charging circuit into the antenna circuit, thus permitting the remainder of the energy to persist as oscillations in the charging circuit.[*]

The principal features of Marconi's transmitter are thus

> i. means for adjusting the charging and antenna circuits to the same frequency by a variable capacity (e) in the charging circuit and a variable inductance (g) in the antenna circuit, and

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[*] When the circuits of an oscillation transformer (such as $d\ d'$ in Marconi's Fig. 1) are coupled tightly, as by the coils being close together or wholly overlapping each other without other provisions for loosening the coupling between the circuits, the reaction of the currents in the circuits produces resonance to waves of two frequencies (known to the art as a "double hump") in the resonance characteristic of the antenna at the transmitter or of the detector circuit at the receiver. This reduces the power applied in generating the desired frequency, and reduces the persistency of oscillation (II R. 900-905; Ex. M-2, Loftin Sketch F; V R. 3590).

> ii. means for making the oscillations in the charging circuit persistent, that is, the low resistance plain spark gap and the loose coupling between the circuits produced by the "swamping" action of the inductance *g*.

Of the claims in suit, claims 1, 3, 6, 8, 11, and 12 relate to the transmitting station. They cover both the charging circuit and the antenna circuit, and provide either for a "variable inductance included in the open circuit" (claims 1, 3, 8, and 12) or "an inductance" (claim 11) or a "means for adjusting the oscillation period of each of the two circuits" (claim 6).

(b) The Receiver: Claims 2, 13, 14, 17, 18, and 19

At the receiving station (Figure 2), the patent specification calls for an oscillation transformer j^2 j^3

> one coil whereof is included between the aerial receiving-wire and earth, constituting a good absorber of electrical oscillations, while a device responsive to electric waves, such as an imperfect contact or a device for operating the same, is included in a circuit with the other coil of said transformer (p. 1, lines 49–56).

The receiver consists of a receiving circuit f' A g' h j' E, and a detector circuit j^2 g^2 h'—T j^3 containing a wave responsive device T, with variable inductances g' and g^2 for adjusting the two circuits to the same frequency. Of the claims in

suit, claims 2, 13, 14, 17, 18, and 19 deal with the receiving station.[9] They cover both the antenna circuit and the detector circuit, and provide for a wave-responsive device in the detector circuit together with "means for adjusting the two transformer circuits" (claims 14 and 17), or for a variable inductance in the antenna circuit (claims 2, 13, 17, 18, and 19).

(c) Tuning: Claims 10 and 20

An essential element of Marconi's system is the tuning of the two circuits at the transmitter and of the two circuits at the receiver to the same frequencies, so that all four circuits will be in electrical resonance with each other. The specification first prescribes tuning the two circuits at each station (p. 1, lines 56–62), and particularly states (this having been added by amendment, IV R. 3955–3967, 3968):

> The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances and the use at both stations of means for varying or adjusting the inductances of the two circuits at each station to accord with each other.

[9] Claim 16, which also relates to the receiving station, is dealt with in the *United States v. Marconi Wireless Telegraph Company of America*, this Term, No. 373.

It then provides for tuning all four circuits (p. 2, lines 118–129):

> The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other.

The variable elements *e g g' g²* constitute the means whereby all four circuits can be adjusted to the same frequency. Claim 10 specifies that the two circuits at each station shall be in electrical resonance with each other, and claim 20 recites that there shall be "means" for bringing the four transformer circuits, two at each station, into electrical resonance with each other.

2. *Wireless Development Prior to the Marconi Patent*

A brief summary of the early development of wireless telegraphy will facilitate a comparison between Marconi's alleged invention in suit and the prior art which the court below found anticipated Marconi.

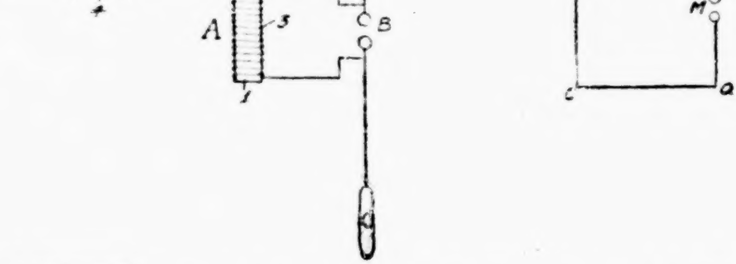
512476—43——3

(a) Hertz' Teachings

Clerk Maxwell at an early date disclosed the theory of wireless telegraphy, and his statements of fundamental laws still serve as the foundation of wireless communication (II R. 858). Maxwell, however, did not reveal any apparatus for utilizing his theory; it was Heinrich Hertz, between 1879 and 1890, who first evolved and demonstrated apparatus for carrying the Maxwellian theory into effect (II R. 869, 872, 873). One form of apparatus used by Hertz and described in a publication of September 21, 1888, was as follows (transmitter on the left, receiver on the right):[10]

(i) *Hertz' Transmitter*

Referring to the transmitter (left), *A* represented an induction coil (or Ruhmkorff coil),



[10] Hertz' work was described by De Tunzelmann in 1888 in a series of articles published in the *London Electrician* (Ex. F-2, bound in reversed order at V R. 3566–3589).

which was already a well-known device. It consisted of an iron core *1*, upon which were wound a primary coil *2*, consisting of relatively few turns of heavy wire, and a secondary coil *3*, consisting of a large number of turns of fine wire, so that an alternating or pulsating current in the primary coil would induce a current of much higher voltage in the secondary coil. The primary circuit of the induction coil consisted of the primary coil *2*, a battery *4*, a circuit breaker *5*, normally held in open position by a spring *6*, and another circuit breaker or "trembler" *7*, normally held closed by a spring *8*, but adapted to be opened by the attraction of core *1* when energized by current in the closed primary circuit. The secondary circuit of the induction coil (the charging circuit for the antenna) comprised the secondary coil *3*, the spark gap or discharger *B*, and the plates or capacity areas *C C*. These capacity areas *C C*, being connected to the spark gap *B*, imparted capacity to this charging circuit and also, with the spark gap *B*, formed the antenna or radiating circuit.

The operation of this transmitter was as follows: Upon closing switch *5*, battery *4* would energize coil *2*, magnetizing core *1* and causing it to attract switch *7*; such attraction would then open the primary circuit and thus demagnetize the core *1*, permitting switch *7* again to close (through its spring *8*) and start the energization

of coil 2, to resume the entire process. As long as switch 5 was held closed, switch 7 was thus caused to "tremble", i. e., to make and break its circuit. The constant making and breaking of the primary circuit induced in the core a rising and falling magnetism which in turn induced an alternating current in the secondary coil 3. The voltage of the current in the latter coil, however, was higher than that in the primary coil 2, in the same proportion that the number of turns of wire in the secondary coil bore to the number of turns of wire in the primary coil.

By connecting the secondary coil to the spark gap or discharger *B*, the voltage built up in the knobs or terminals of the gap would ionize the air between them until the insulating effect broke down, causing a spark to leap across the gap from knob to knob. So long as the switch 5 was closed, a succession of sparks was caused to pass across the gap of the discharger, and during the continuation of each spark, a high-frequency oscillation of current occurred in the circuit *C B C*, consisting of several "swings" or impulses steadily decreasing in amplitude. As long as the primary circuit was closed there would occur a succession of these group oscillations.

By connecting the spark gap to the plates *C C* in the antenna circuit, which had a large area, capacity areas were provided for receiving a large charge of current from the induction coil,

thus increasing the power of the transmitting system. The frequency or wave length to which a circuit resonates or vibrates (the "fundamental" of the circuit), and thus the wave length of the oscillations it can generate, is determined by the circuit's inductance (length and disposition of the straight or coiled-up wire in the circuit) and capacity (area of and distance separating charged metal surfaces in the circuit, as the plates *C C*). Consequently, the additional capacity areas *C C*, as Hertz recognized (see n. 12, p. 34, *infra*), changed one of the two components determining the frequency of the oscillations in the circuit and thus constituted a means modifying or adjusting the frequency of its oscillations. This was one of the first principles in tuning.

(ii) *Hertz' Receiver*

Hertz' receiver comprised a loop or ring of wire, shown in the form of a rectangle half a meter in length, the ends being connected to the knobs of a spark gap or micrometer *M*. In the apparatus illustrated above (p. 30), the terminal conductors of the transmitter, *C* and *C*, "were three meters apart" while the receiver or "micrometer circuit" consisted of a "rectangle 80 centimeters broad by 120 centimeters long" (Ex. F-2; V R. 3585).

These measurements are significant in demonstrating Hertz' awareness of the principles of

tuning or synchronization, for the dimensions of Hertz' receiving circuit (the inductance) were so chosen, and the spacing of his micrometer knobs *M* (determining the capacity between them) was intentionally so adjusted as to render the circuit resonant to the wave length of his transmitter.[11]

There is thus no doubt that the principles of resonance, so universally employed in all wireless apparatus, were understood and applied by Hertz in determining the constants for his receiver (i. e., the length of wire and the micrometer dimensions) and that he selected those constants which would cause his receiver to resonate to the transmitted wave length.[12]

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[11] This is revealed in Hertz' own detailed description of his apparatus (Ex. J 4; V R. 3891) and was recognized by Lodge (see p. 36, *infra*).

[12] De Tunzelmann recognized this in 1888. He wrote that in order to determine whether "the oscillations were of the nature of a regular vibration," Hertz "availed himself of the principle of resonance," according to which "an oscillatory current of definite period would, other conditions being the same, exert a much greater inductive effect upon one [i. e., a receiving circuit] of equal period than upon one differing even slightly from it.

"If, then, two circuits are taken having as nearly as possible equal vibration periods, the effect of one upon the other will be diminished by altering either the capacity or the coefficient of self-induction of one of them, as a change in either of them would alter the period of vibration of the circuit." (V R. 3585.)

Prof. Ebert also recognized in 1894 that the Hertz receiver was "electrically tuned" to resonance, and that he used "tuned circles of wire." (V R. 3888.)

(iii) *Lodge's Observations on Hertz' Teachings*

After about six years, during which the work of Hertz attracted wide attention, Sir Oliver Lodge in 1894 published a series of articles in the *London Electrician*[13] describing and explaining Hertz' teachings by diagrams corresponding to those now in common use. In an article of June 8, 1894, he explained the elementary principles in precisely the way they are explained today:

> Conversely, if the source is a persistent vibrator, correct tuning is essential, or it will destroy at one moment motion which it originated the previous moment. Whereas, if it is a dead-beat or strongly damped excitor, almost anything will respond equally well or equally ill to it. * * *
>
> Furthermore, any conductor electrically charged or discharged with sufficient suddenness must emit electrical waves into the ether, because the charge given to it will not settle down instantly, but will surge to and fro several times first, and these surgings or electric oscillations must, according to Maxwell, start waves in the ether, because at the end of each half swing they cause electrostatic, and at the middle of each half swing they cause electromagnetic effects, and the rapid al-

[13] This series of articles, June 8 to July 20, 1894, is in evidence as Exhibit E-4. (V R. 3872.)

ternating from one of these modes of energy to the other constitutes etherial waves.

Maxwell and his followers well knew that there would be such waves; they knew the rate at which they would go, they knew that they would go slower in glass and water than in air, they knew that they would curl around sharp edges, that they would be partly absorbed but mainly reflected by conductors, that if turned back upon themselves they would produce the phenomena of stationary waves, or interference, or nodes or loops; it was known how to calculate the length of such waves, and even how to produce them of any required or predetermined wave length from 1,000 miles to a foot. * * *

Electric syntony.—That was his [Hertz'] discovery, but he did not stop there. He at once proceeded to apply his discovery to the verification of what had already been predicted about the waves, and by laborious and difficult interference experiments he ascertained that the previously calculated length of the waves was thoroughly borne out by fact. These interference experiments in free space are his greatest achievement. (V R. 3873–3874.)

The range of wave lengths given by Lodge—from one foot to 1,000 miles—includes the entire range of what are sometimes called radio frequen-

cies and a very large part of the range of the so-called audio-frequencies.[11]

The Lodge papers also pointed out that several different types of detecting device could be employed in the receiving circuit to detect or ascertain the existence of the transmitted wave: spark gaps, telephones, vacuum tubes, galvanometers and even a pair of frog's legs used by Hertz and Ritter. (V R. 3876-7.)

(iv) Summary of Hertz' Disclosures

Thus from the work of Hertz the art was informed that by applying to a spark gap current of a voltage sufficiently high to break down the gap and to send the current across it, an oscillating electrical discharge of high frequency (now known as "Hertzian waves") would be caused in

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[11] Wave lengths are expressed today in terms of meters, or more commonly in terms of cycles or frequency. A wave length of 1,000 miles is the same as one of 1,584,000 meters, or 186 cycles per second—an extremely long wave length. A wave length of one foot is the same as a wave length of three-tenths of a meter or 982,080,000 cycles per second—an extremely short wave length.

The ordinary human ear can hear sound wave frequencies ranging from 16 cycles up to about 10,000 cycles per second; some extremely sensitive ears may hear such frequencies as high as 30,000 cycles. The range of radio frequencies may be said to be from 30,000 cycles per second up to 1,500,000 cycles per second (I R. 311). There is no fixed dividing line between radio frequencies and audio-frequencies (i. e., those corresponding to the frequencies of audible soud waves) but as a sound frequency rises above 6,000 cycles per second it begins to become inaudible to human ears.

the spark gap or charging circuit and would be communicated to the antenna circuit; that these high frequency waves would propagate ether waves of the same frequency, which could be intercepted by a receiving circuit at a distance; that either mechanical detectors or vacuum tubes could be employed as detector devices in the receiving circuit; that by tuning the antenna and the receiving circuits to the same frequency the maximum response would be obtained; and that the plain gap circuit was a "persistent vibrator."

Hertz did not discover the principles of resonance; they were already well known. He did, however, appreciate from the beginning that in view of the minute values of the energy utilized in the receiving apparatus, tuning to resonance would be essential to almost all practical apparatus, in order that the transmitted waves might be effectively received.

The basic soundness of the Hertz disclosures, and their faithful embodiment in most wireless systems, were judicially recognized in 1905. *Marconi Wireless Telegraph Co. of America* v. *DeForest Radio Telephone & Telegraph Co.*, 138 Fed. 657 (C. C. S. D. N. Y.).[15]

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[15] The court there said: "The means for the later development of wireless telegraphy were furnished in the proof by actual experiment of the correctness of certain theories promulgated by Prof. Maxwell, of Cambridge, in 1865, that electricity, like light, traversed space through the medium of ether, and that, if a spark be created by a disruptive dis-

(b) Marconi Prior Patent No. 586,193

Marconi in a patent antedating by seven years the one here involved also recognized the principles of resonance, and tuned the antenna circuit of his receiver to accord with the antenna circuit of the transmitter. This prior patent No. 586,193, covering Marconi's earliest invention, was granted July 13, 1897, upon an application filed December 7, 1896, and was reissued as Reissue patent No. 11,913 on June 4, 1901 (Ex. 19, IV R. 2567). It disclosed the following transmitter (Fig. 10) and receiver (Fig. 11), both substantially like Hertz' apparatus:

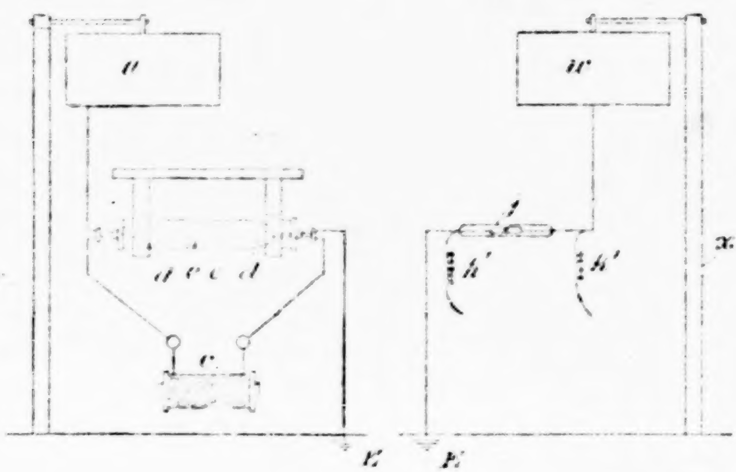
At the transmitting station (Fig. 10), the 1897 Marconi patent showed a Ruhmkorff coil c [16] which

charge, it will spread out in waves or undulations. These waves are known as 'Hertz waves' or 'Hertz oscillations,' from the name of their discoverer, Heinrich Hertz. He produced these waves by the use of an apparatus consisting of a radiator and a receiver equipped with rods having small metallic knobs on the ends, and separated a short distance from each other. This separation is the spark-gap, by means of which the Hertzian waves or oscillations are produced. When the transmitter or radiator is connected with a Ruhmkorff coil, or any source of high electric tension, such as an induction coil, with mechanical vibrator, or a producer of electric current, such as a dynamo, a charge of electricity is sent through the circuit which includes the spark-gap, and a spark passes across the spark-gap and creates the electrical vibration or wave called the 'Hertz wave'" (p. 658).

[16] This coil, as shown in Fig. 1 of the patent (IV R. 2569) was the usual Ruhmkorff coil shown in the illustration on p. 30, *supra*, and had the customary key in its primary or battery circuit.

delivers a high tension, high frequency current to the spark gap, *d e e d* in the secondary circuit of the coil. One side of the spark gap is grounded at *E* and the other side connected to an elevated wire and plate *u* insulated from the earth on the pole *v*.

Fig. 10. Fig. 11.



At the receiving station (Fig. 11), a coherer *j* is inserted in the antenna circuit *w E* as the detector device. The coherer, a tube containing a rather coarse metallic powder, normally prevents flow of current in the local battery circuit (connected to choke coils *k' k'* but not shown in Fig. 11), but as soon as an impulse is received by the antenna circuit the metallic particles are caused to cohere,

so as to provide a conductive path closing the battery circuit, thereby causing a signal. Choke coils *k' k'* are provided to keep high frequency waves out of the local battery circuit. A relay in the battery circuit operates a stronger battery circuit containing a sounder and a trembler for tapping the coherer so that its circuit will be broken after the incoming waves have ceased (Ex. 19; Findings IX and X, I R. 12, 13). Metal plates are used for tuning, "preferably of such a length as to be electrically tuned with the electric oscillations transmitted" (Ex. 19, p. 3, lines 28–30; IV R. 2574).

In this Marconi patent the apparatus is substantially the same as that disclosed by Hertz, with the following exceptions: (i) Hertz, unlike Marconi, did not employ the earth as one of the capacity areas of his transmitter or use similar capacity areas at the receiver, and (ii) Marconi, unlike Hertz, used a coherer as the detector device in his receiver.

3. *Prior Art Anticipating Marconi's Patent No. 763,772*

Following the development in the art discussed above, came disclosures which the court below found anticipated Marconi's patent here involved.

The art thus held to invalidate the Marconi patent consisted of prior inventions by Tesla, Lodge, Stone and Marconi himself. These disclosures antedated the earliest date which Marconi is entitled to claim for his alleged invention in patent No. 763,772—viz., November 10, 1900, the filing date of his application (Finding XLI, I R. 37). Consequently, the propriety of the conclusion below that the prior art invalidated Marconi's patent depends upon whether the anticipating disclosures and Marconi's device were substantially the same in structure, mode of operation and effect. We submit that such substantial similarity was properly found to exist.

(a) Tesla Patent No. 645,576

Tesla patent No. 645,576, granted March 20, 1900 upon an application filed September 2, 1897, disclosed two circuits (one open and one closed) at both the transmitter and the receiver, and provided for synchronizing or tuning these circuits together. The following apparatus was shown in the Tesla patent (Ex. X-2, V R. 3602):

In the transmitter (left-hand figure), high frequency oscillations are delivered from the source *G* to the primary coil *C* of an oscillation transformer.[17] The secondary coil *A* of the oscillation

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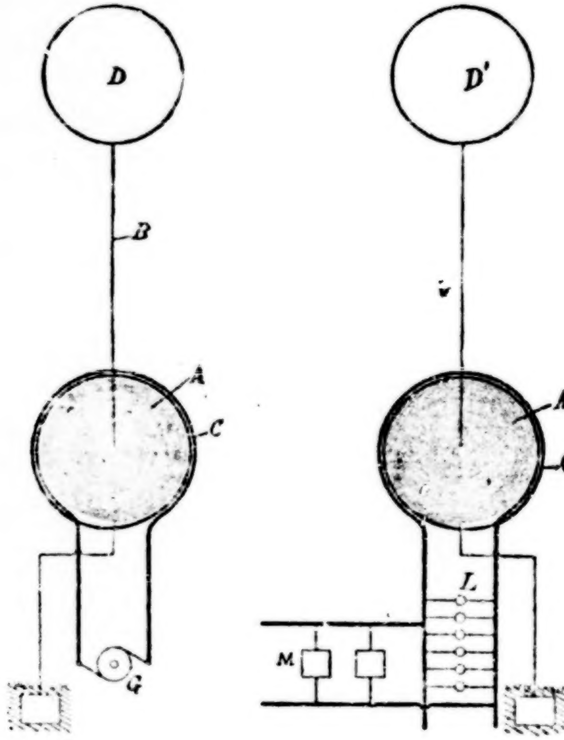
[17] The source *G*, "one of the elements of the transmitter," is described in the Tesla patent as "a condenser of a capacity of about four one-hundredths of a microfarad * * * charged from a generator of alternating currents of fifty



transformer, which has many more turns than the primary coil C, is connected at one end to earth and at the other end to an aerial B D. Thus the primary or charging circuit automatically causes oscillations of the desired frequency and delivers them to the open or antenna circuit, from whence they are radiated into space.

In the receiver (right-hand figure), a similar transformer is employed, except that it is the

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thousand volts' pressure and discharged by means of a mechanically-operated break five thousand times per second through the primary C" (Ex. X-2, p. 3, lines 117-125, V R. 3605.)

primary coil A' which is of thin wire and which has more turns than the other, the secondary coil C'. Tesla contemplated primarily the transmission of waves sufficiently powerful to operate motors and the like, for in the secondary circuit he included lamps L, motors M "or other devices for utilizing the current" (Ex. X-2, p. 3, lines 24-26; V R. 3605). However, he also recognized that this method of energy transmission, without change of apparatus, could be used for wireless communication (p. 5, lines 28-35; V R. 3607):

> The apparatus which I have shown will obviously have many other valuable uses — as, for instance, when it is desired to transmit intelligible messages to great distances * * *.

Since the transmission of intelligible messages to great distances involved no change of apparatus disclosed, and was merely dependent upon the use of the usual key to interrupt the power supplied through the source G at the transmitter, Tesla clearly disclosed to those skilled in the wireless telegraphy art an open aerial circuit coupled to a closed charging circuit at the transmitter, and an open aerial circuit coupled to a closed detector or receiving circuit at the receiver.

Moreover, as the court below properly found (Finding LXXII, I R. 58), Tesla instructed those skilled in the art that the open and closed circuits of the transmitting system and the open and

closed circuits of the receiving system should be in resonance with each other; in other words, that all four circuits should be in resonance. The Tesla patent states that the "primary and secondary circuits in the transmitting apparatus" are "carefully synchronized", this synchronism being attained—

> When the primary coil or system *A'*, with its secondary *C'*, was carefully adjusted, so as to vibrate in synchronism with the transmitting coil or system *AC*. (Ex. X-2, p. 4, lines 27-29; V R. 3606).[8]

Thus, Tesla concentrated most of his inductance in the form of coils in his antenna circuits, and adjusted this inductance by adjusting those coils, so tuning his circuits. Indeed, in 1899 Stone recognized "four-circuit" tuning as Tesla's contribution (see p. 69 and note 28, *infra*).

[8] Tesla's teaching in this respect is further set forth in his prior art patent No. 649,621 granted May 15, 1900, upon a division of the application for patent No. 645,576, wherein he says (Ex. L-6, p. 1, line 97 to p. 2, line 10; V R. 4090, 4091):

"It will be readily understood that when the above-described relations exist the best conditions for resonance between the transmitting and receiving circuits are attained, and owing to the fact that the points of highest potential in the coils or conductors *A A'* are coincident with the elevated terminals the maximum flow of current will take place in the two coils, and this, further, necessarily implies that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations."

It is thus clear that Tesla disclosed and anticipated the following features of the Marconi patent: (i) a charging circuit in the transmitter for causing oscillations of a desired frequency, (ii) an aerial or antenna circuit in the transmitter coupled through a transformer to the charging circuit for transmitting these oscillations, and (iii) the synchronizing of these two circuits by adjusting the inductance in the antenna circuit. Moreover, by disclosing the same arrangement in the receiver, Tesla anticipated the four-circuit tuning combination of Marconi.

The only feature in Marconi's arrangement which was absent from Tesla's—the use of a "variable inductance" in the antenna circuit of the transmitter and receiver as the tuning medium—was found in the Lodge disclosure prior to Marconi, as we shall show.

(b) Lodge Patent No. 609,154

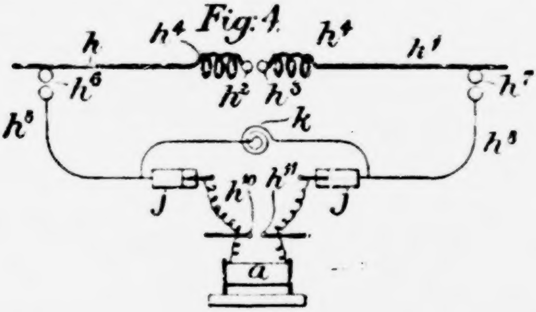
In patent No. 609,154, granted August 16, 1898, upon application filed February 1, 1898 (Ex. 20, IV R. 2581), Sir Oliver Lodge disclosed, prior to Marconi, a variable inductance coil in a wireless transmitter or receiver to enable them to be tuned together. The finding of the court below to this effect (Finding XXIX, I R. 26) is clearly sustained by substantial evidence.

Lodge's patent provided for a self-inductance coil *h*' between a pair of capacity areas *h* and *h*'

(which, he disclosed, may be antenna and earth respectively) in an oscillating circuit of either a sending or receiving set (or both) for Hertzian wave telegraphy. The patent disclosed that such coil should be made adjustable at will to vary the value of its self-inductance. Lodge explained that the adjustment, that is, "the desired frequency of vibration or syntony with a particular distant station," may be attained by a coil itself capable of adjustment, or

> by replacing one coil by another, for the frequency can be adjusted either by varying the capacity of the condenser or jar or other conductor employed or the charged body on the one hand or by varying the number and position of coils or other portion of the discharge-circuit on the other (Ex. 20; IV R. 2585, lines 39–48).

The transmitter was illustrated as follows in Figure 4 of the patent:



As decribed in the specification, the transmitter contained three or four spark gaps (h^{10}–h^{11}, h^6, h^7, and optionally h^2–h^3), instead of the usual single

spark gap. The effect of this was to cut off quickly the arc of energy in the charging circuit, and, with the aid of tight coupling between the open and closed circuits, to transfer the energy quickly from the closed to the open circuit,[illegible] i. e., in "an impulsive rush." (Ex. 20; IV R. 2584, lines 72-75).

The Marconi patent, claims 1 and 3, describe the open circuit of the transmitter simply as "electrically connected with" the charging circuit, and as containing a variable inductance. These Marconi claims do not require an oscillation transformer in the transmitter, nor the tuning of the open and closed circuits; consequently, as the court below properly found (Findings LXI; I R. 57), they read directly upon the auto-transformer arrangement in Figure 4 of the Lodge patent and are anticipated.[illegible]

As the court below found, the Lodge patent also described and claimed a variably acting self-inductance coil in a transmitter or receiver, to enable the transmitter and the receiver to be tuned together (Finding XXIX; I R. 26). The adjustable inductance of the Lodge patent is set

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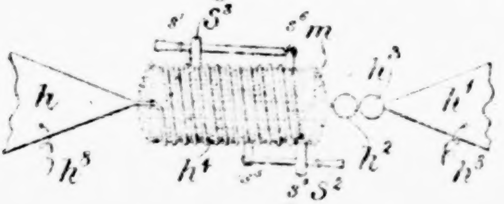
All of the inductance $k^1 k^4$ is common to the charging circuit and the antenna circuit, hence the coupling between the two oscillatory circuits is tight. When two circuits are each connected to include a common coil, the coil is called an "auto-transformer."

The similarity between the two devices is plainly to be seen from a comparison of Figure 1 of the Marconi patent (*supra*, p. 24) with Loftin's simplified sketch of Lodge's Figure 4 (*infra*, p. 50).

forth in Figure 9 of his specification (following), in which the switches s' s^6 are so related to the inductance coil h^4 as to short-circuit any desired number of turns of the coil to adjust its effective inductance and thus tune the circuit.

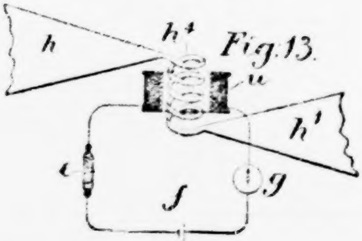
Fig. 9.



The two forms of receiver in the Lodge patent are shown in Figures 12 and 13:

Fig. 12.

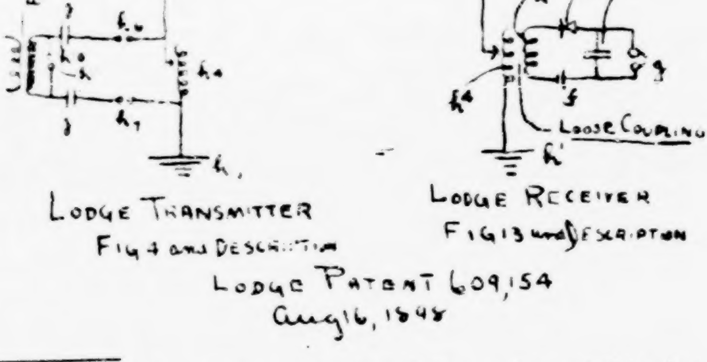
Fig. 13.



In Figure 12, the detector circuit e f g is directly coupled to the terminals of the inductance coil h^4 in the antenna circuit; in Figure 13, the two circuits are inductively coupled through a

transformer having the primary coil h^4 in the antenna circuit and the secondary coil u in the detector circuit. The element w in Figure 12 is either a resistance or a capacity (IV R. 2586, line 65), which may be used across the instrument g, i. e. in circuit with coherer c in Figure 13 (IV R. 2586, line 62).

The following simplified sketch submitted by defendant's witness Loftin presents, in the conventional diagrammatic form, the Lodge transmitter of Figure 4 and the Lodge receiver of Figure 13, with antenna and earth as the capacity areas, as previously taught by Marconi in patent No. 586,193 (pp. 39–40, *supra*),[23] and as contemplated by Lodge (Ex. 20, IV R. 2584, line 37 and lines 103–107; and Figs. 6 and 7, IV R. 2581):



[23] Ex. V-2, IV R. 3600. Loftin fully explained this sketch and the operation of Lodge Fig. 4 at II R. 946–952.

The only feature in Marconi which was not shown in Tesla's system was the use of a variable inductance in the antenna circuit of the transmitter as the tuning medium to vary its periodicity, instead of accomplishing the same result by selection of a proper fixed inductance. But, as shown above, this more convenient mode of effecting the tuning specified by Tesla was shown by Lodge before the earliest date attributable to Marconi. Since Lodge's variable inductance was the only feature which Marconi combined with Tesla's system of tuning the two transmitter circuits to the same frequency, the court below correctly held (I R. 98) that Tesla, read in conjunction with Lodge, anticipated all of Marconi's claims for four-circuit tuning.[22]

Indeed, the court might properly have found that Lodge alone fully anticipated the receiver

[22] The court below made evidentiary findings of fact explaining the structure and mode of operation of Tesla's disclosure of four-circuit tuning (Finding LXII, I R. 58-59) and of Lodge's showing of a variable inductance coil as an instrumentality for effecting tuning (Finding XXIII, I R. 23). It also made evidentiary findings as to the structure and operation of Marconi's four-circuit tuning (Findings XXXVIII, XLIII, XLVII; I R. 31-40, 42). While it made no "findings" labeled as such, that Tesla and Lodge anticipated particular claims of Marconi, such "findings" are mere conclusions readily to be drawn from a simple comparison of the appropriate evidentiary findings, and are in any event implicit in the ultimate finding made by the court as to invalidity of the Marconi patent, as its opinion in fact reveals (I R. 97-99).

claims of Marconi's patent here involved. These claims (2, 13, 14, 17, 18, and 19) were directed to the combination of an oscillation receiving conductor (the antenna circuit), a wave responsive device electrically connected with the conductor (the detector circuit), and a variable inductance in the antenna circuit (claims 2, 13, and 18), or "means for adjusting the two transformer circuits in electrical resonance with each other" (claims 14 and 17). As the court below found (Findings LIX and LXI, I R. 57), none of these claims actually require that the two circuits shall be in resonance with each other; they require only that there shall be means for making the adjustment, the means shown being an adjustable inductance in the antenna circuit. Lodge's patent alone, as shown above, fully disclosed the use of the variable inductance coil for tuning the antenna circuit; consequently, no invention was involved in Marconi's employing the Lodge variable inductance for adjusting the circuits in lieu of making the adjustment by varying the length of the wire or the size of fixed coils, especially since no new function was imparted thereby either to the circuits or to the variable inductance.[23] Merely making known elements ad-

[23] The court below also found (Finding LXI, I R. 57) that claim 2 of Marconi's receiver group was the same in structure and operation as Figure 13 of the Lodge patent, and

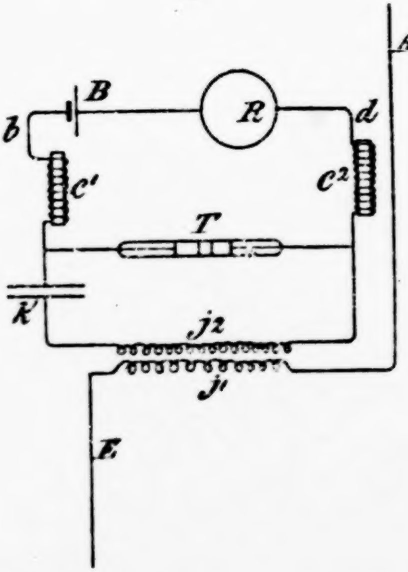
justable, when no new or unexpected result is attained thereby, is not invention, particularly when the prior art shows such adjustability to be known in the same or analogous uses, *Peters* v. *Hanson*, 129 U. S. 541, 550–551.

(e) Prior Art Marconi Patent No. 627,650

As the court below found (Finding LII, I R. 46), the principle of tuning the respective circuits of the receiver (and transmitter) by varying inductance coils to accord with the varying wave lengths, was also brought out in the prior art Marconi patent No. 627,650, granted June 27, 1899, upon an application filed January 5, 1899 (Ex. P–5, same as Ex. B–6, V R. 4085–8). The receiver described in this patent was illustrated in Figure 1 as follows:

hence anticipated by it. This is fully sustained by the evidence. Marconi's claim 2 is not limited to the tuning of the open and closed circuits, nor to a variable inductance used in addition to the transformer primary coil. Lodge's Figure 13, with condenser *w* of Lodge's Figure 12 connected in circuit with coherer *e* as described by Lodge (p. 50, *supra*), satisfied every requirement of Marconi's claim 2. Indeed, that claim does not even require an oscillation transformer, and is thus directly applicable to Figure 12 of Lodge as well.

Fig. 1.



In it, Marconi employed a coupling transformer j' j^2 which he referred to as an "induction coil," the antenna or aerial conductor A being connected to the primary winding j' of the "induction coil" and thence grounded to earth E. The secondary winding j^2 of the coil was in the detector circuit, and a coherer T (described as an "imperfect contact") was connected to the ends of the secondary winding of the coil, through a variable condenser k' (id., V R. 4087, lines 14–20). The specification recited that:

> It is desirable that the induction-coil should be in tune or syntony with the electrical oscillation transmitted, the most appropriate number of turns and most appro-

> priate thickness of wire varying with the length of wave of the oscillation transmitted.
>
> The capacity of the condenser on the connection between the imperfect contact and the secondary of the coil should be varied (in order to obtain best effects) if the length of wave is varied. (id., lines 31–42).

As was pointed out by defendant's expert witness Loftin (II R. 951), these are clear directions to tune the respective circuits, by means of the variable inductance in the antenna circuit and the variable condenser in the detector circuit. The apparently contrary statement of plaintiff's expert witness Weagant that varying the condenser *k'* would be "totally incapable of tuning the receiving circuit" (II R. 1627) is the result of a confusion between the effect of resistance and the effect of inductance and capacity. *Resistance*, it is true, does not affect the tune or frequency of the circuit, and merely affects the amplitude of the wave, whatever its frequency. But it is clear that changing the *capacity* does affect the tune. This was brought out by Marconi himself, who in effect contradicted Weagant's testimony as follows (I R. 539):

> How do you tune a coherer circuit?
>
> A. We tune it by proportioning the inductance and the capacity of the circuit

> in which it is, so that that circuit will be in tune with the oscillations which you want to receive.

The tuning of the two receiver circuits by using a variable inductance in the antenna circuit was the subject matter of claims 2, 13, 18, and 19 of Marconi's patent in suit (see pp. 27–28, *supra*). Since Marconi's earlier patent in 1899 disclosed such tuning by the use of an "induction coil" containing "the most appropriate number of turns" and by the use of a variable condenser in the secondary winding of that coil, the finding of the court below that Marconi's earlier patent anticipated claims 2, 13, 18, and 19 in suit is fully sustained by substantial evidence.

(d) Stone Patent No. 714,756

(i) *Stone's Disclosures*

Also before the earliest date for Marconi's alleged invention (November 10, 1900) John Stone Stone clearly disclosed the tuning of the aerial circuits of wireless apparatus by inductance, and the tuning of the open and closed circuits of the transmitter and receiver, all four to the same frequency. This disclosure was made by Stone in a patent application filed February 8, 1900, upon which patent No. 714,756 was granted on December 2, 1902 (Ex. P–3, V R. 3648.) While Stone did not describe the partic-

ular means for adjusting the frequency of the aerial, he did prescribe adjusting the value of the inductance to the desired frequency, and to one skilled in the art this meant the use of a variable inductance, such as had previously been disclosed by Lodge patent No. 609,154, for example (Finding LVII, I R. 56).

Stone's patent explained in great detail the effect of one circuit upon another, and showed that in a *single* tuned circuit there is a "single degree of freedom," i. e., one natural period in which the current oscillates with freedom, whereas if *two* such circuits are coupled together, there will result a system of "two degrees of freedom," i. e., the super-position of two frequencies. Stone then described the following transmitter (Figure 5) and receiver (Figure 6):

Fig. 5.

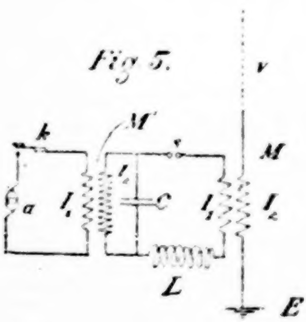
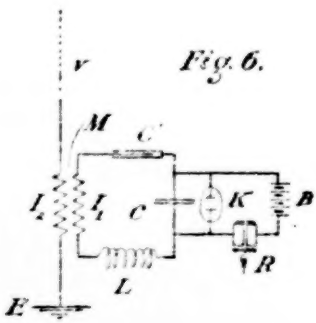


Fig. 6.



The transmitter (Fig. 5) had a telegraph key *k* in the primary winding I'_1 of an induction coil *M'*. In the secondary winding I'_2 of this induction coil there was a spark gap *s* which generated high-frequency oscillations through the closed cir-

cuit $s\ C\ L\ L_1$. This circuit was electrically connected, through an oscillation transformer M, with an open or antenna oscillating circuit $v\ L_2\ E$.

The receiver (Fig. 6) comprised an open oscillating circuit $v\ L_2\ E$, inductively coupled through the transformer M with a closed oscillating circuit $L\ C''\ C\ L$. A coherer or wave-responsive device K was connected across the condenser C.

In his specification, Stone disclosed two systems of four-circuit tuning, one of which the court below held anticipated Marconi. In that system Stone disclosed tuning the open and closed circuits at the transmitter and receiver, all to the same frequency or wave length.[24] For this purpose, at the transmitter he adjusted the charging circuit ($C\ s\ L_1\ L$) to the desired frequency, and preferably adjusted the antenna circuit to be resonant to the same frequency, thus tuning the two transmitter circuits to the desired wave length; at the receiver he tuned the antenna circuit to the incoming frequency, and tuned the detector circuit to the antenna circuit. This is to be seen

[24] For the other system, a multiplex arrangement, Stone proposed employing two tuned circuits at the transmitter and two at the receiver, all tuned to the same wave length, those at the transmitter forcing the selected wave length on an aperiodic antenna circuit, and those at the receiver receiving the selected wave length from an aperiodic antenna circuit. The aperiodic antennas used in this form of Stone's system were ones capable of radiating or absorbing any one of a number of wave lengths in the range of wave lengths to be employed. Figures 13, 14, 16 and 17 of the Stone patent relate to this system.

from the following statements in his specification referring to the transmitter:

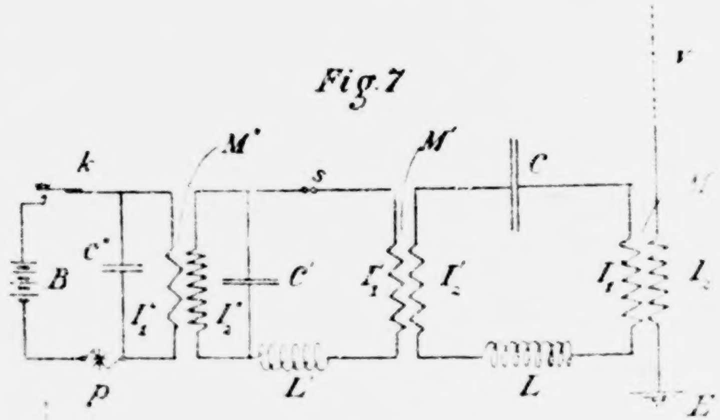
> Thus the frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor (Ex. P–3; V R. 3648, lines 16–20).
>
> The vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency, and the harmonic vibrations impressed thereon may with advantage be of that frequency (Ex. P–3; V R. 3653, lines 62–66).

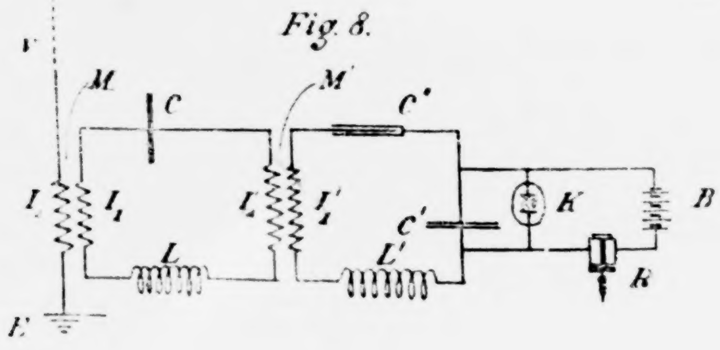
And with respect to the receivers:

> When the apparatus at a particular station is attuned to the same periodicity as that of the electromagnetic waves emanating from a particular transmitting-station, then this receiving-station will respond to and be capable of selectively receiving messages from that particular transmitting-station to the exclusion of messages simultaneously or otherwise sent from other transmitting-stations in the neighborhood which generate electromagnetic waves of different periodicities. Moreover, by my invention the operator at the transmitting or receiving station may at will adjust the apparatus at his command in such a way as to place himself in communication with any one of a number of stations in the neighborhood by bringing his apparatus into resonance with the periodicity em-

ployed by the station with which intercommunication is desired (Ex. P-3; V R. 3651, lines 17-36).

Indeed, further to insure that only the one desired fundamental frequency would be transferred at the transmitter from the charging circuit to the antenna circuit, and at the receiver from the antenna circuit to the detector circuit, Stone proposed that another closed circuit be interposed between the closed (charging or detecting) circuit and the open (antenna) circuit of transmitter and receiver, as shown in Figures 7 and 8, respectively, of his patent:





In respect of the transmitter (Figure 7), the specification states:

> In the transmitter arrangements illustrated in Figure 7 the circuit CI'_2 LI_1 is attuned to the same period as the circuit C' L' I'_{3} and merely tends to weed out and thereby screen the vertical wire from any harmonics which may exist in the current developed in the circuit C'' L' I'_{3} (Ex. P–3; V R. 3653, lines 89–94).

And in respect of the receiver (Figure 8), the specification states:

> In the organization illustrated in Figure 8 the electric resonator CI'_2 LI_1, interposed between the vertical conductor and the circuit containing the coherer is attuned to the same period as the circuit L' C' C'' I'_1 and acts to screen the coherer-circuit from the effect of all currents developed in the vertical conductor, save that of the current of the particular period to which the receiving-station is intended to respond (*id.*, lines 122–131).

The Stone disclosures thus fully support the finding below that Stone tuned the closed circuit of his receiver and transmitter "to the frequency of the transmitted signal," and that from his suggestion to tune the open transmitter circuit "it was obvious to one skilled in the art that the receiver open circuit should also be tuned." Indeed, as the court further found, Lodge among others had earlier disclosed the desirability of

such tuning and the manner of accomplishing it (see pp. 47–48, *supra*), and the disclosure and first claim of Stone's application as filed had suggested it.[26a] In short, "to one skilled in the art, Stone's patent contemplated having all four oscillating circuits in tune or accord with each other" (Findings LIII and LVII; I R. 47, 50, 56–57).

The court recognized that the Stone patent drawing made no attempt to show adjusting of the condensers or inductances in any of the oscillating circuits, but found that "one skilled in the art at the time knew how to adjust any or all of them to obtain the desired resonance in the open and closed circuits" (Finding LIII, I R. 47, 50). This finding is equally supported by the evidence. Lodge, among others, had informed the art how to adjust the inductances (see p. 49, *supra*) and easily adjustable condensers were also well known at this time, having been shown by Marconi himself in a prior patent (pp. 54–55, *supra*) and by Tesla in 1894 (Ex. B-4; V R. 3839, 3840–3841). Consequently, the Stone patent was correctly found to anticipate Marconi with respect to adjustable four-circuit tuning.

Plaintiff attacks the Stone defense, asserting that the description of tuning the open antenna

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[26a] The specification as filed also shows clearly Stone's understanding that any coupled circuits would be tuned to resonance in obtaining the single frequency by his loose coupling arrangement. (V R 3653, lines 98–102; see also footnote 26b, p. 64, *infra*.)

circuits was inserted in the Stone application by amendment in April 1902, after Marconi's application was filed on November 10, 1900. This contention is in effect that the 1902 amendment of Stone's application departed from the original disclosure and for the first time introduced the matter of tuning the antenna circuits. But the record completely disproves this.

In claims 1, 3, and 4 of his application as originally filed, Stone claimed producing the same wave length or frequency in both circuits (Ex. R-3; V R. 3685, 3708). His original specification explained that the antenna or vertical conductor "is made the source of electromagnetic waves of but a single periodicity" (V R. 3697), and directed that the closed circuit should be tuned to the desired frequency, that the closed and antenna circuits should be "loosely" coupled, and that the coupling between these circuits should be adjusted to impart the desired single frequency to the antenna circuit (V R. 3697–9). These directions necessarily amounted to a disclosure that the antenna currents of both transmitter and receiver would be of the same frequency.[25] Moreover, Stone's original specification had made clear that if but one frequency was to be transmitted, the apparatus would correspond to a tuning fork (V R. 3698), whereas when the elevated conductor was aperiodic several fre-

[25] I R. 770, last two paragraphs, and particularly last three lines. (See also footnote 26, p. 64, *infra.*)

quencies would be transmitted. This in effect was a statement that the elevated conductor was *not* aperiodic when only one frequency was to be transmitted.[24] The subject of the 1902 amendment, which merely explained these matters in more detail, was thus plainly found in the original disclosure. Indeed, if plaintiff's contention had any foundation, it would have been the duty of the Patent Office examiner to have refused the 1902 amendment, as containing matter not shown, described or suggested in the original specification.[25] The absence of any indication in the record that the examiner had the slightest difficulty in allowing the amendment, coupled with the presumption that public officers have properly performed their duties,[26] require the conclusion that the tuning of the antenna circuits had been sufficiently disclosed in the original application to be apparent to the examiner as one skilled in the art at the time.[27]

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[24] I R. 769–770; see also footnote 21, p. 62, *supra*.

[25] *Western Elec. Co. v. Sperry Elec. Co.*, 58 Fed. 186, 196 (C. C. A. 7); *Individual Drinking Cup Co. v. Errett*, 300 Fed. 955, 959 (S. D. N. Y.); *Diamond Power Specialty Co. v. Bayer Co.*, 13 F. (2d) 337 (C. C. A. 8).

[26] *United States v. Crusell*, 14 Wall. 1, 4; *United States v. Chemical Foundation, Inc.*, 272 U. S. 1, 15; *In re State Thread Co.*, 126 F. (2) 296, 299 (C. C. A. 6); *Atchison, T. & S. F. Ry. v. Elephant Butte Irr. Dist.*, 110 F. (2) 767, 771 (C. C. A. 10).

[27] When a "single frequency" is to be attained by loosely coupled circuits, the circuits *must* be attuned to the same natural period (I R. 770).

But even if the disclosure of tuning the open circuits had not been complete in the original application and had been supplemented by the 1902 amendment, it would not deprive Stone of priority. For the record shows that long before Marconi's date Stone had conceived four-circuit tuning (including tuning of the antenna circuits as previously taught by Lodge); that Stone had recorded this conception and disclosed it to others as early as June and July 1899; and that during the intervening period Stone was diligent in reducing the invention to practice and in obtaining capital to exploit his invention.

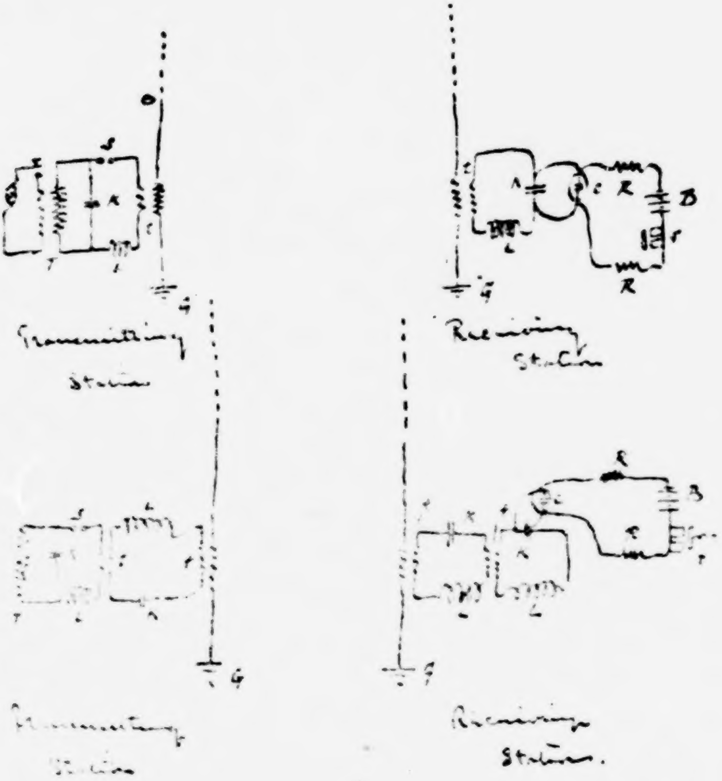
(B) Stone's Disclosures Prior to His Patent Application

In the summer of 1899, Stone disclosed his four-circuit tuning system to his friend, Mr. J. B. Baker, who was also skilled in the art, and who corroborated the disclosure (I R. 735, 738, 739). Stone's letter of June 30, 1899, to Baker, reads in part as follows:

> Instead of utilizing the vertical wire itself at the transmitting station as the oscillator, I propose to impress upon this vertical wire, oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire. Similarly, at the receiving station, I shall draw from the vertical wire, only that component of the complex wave which is of lowest frequency.
>
> If now the fundamental of the wire at the receiving station be the same as that

of the wire at the transmitting station, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting it may not receive those signals.

*   *   *   *   *



In these sketches, *G* is ground, *K* is condenser, *C* is coherer, *L* is inductance coil without iron, *T* is step-up transformer, *t* is transformer without iron, *R* is retardation coil, *B* is battery, *r* is relay.

The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically.

though the best general proportions may be determined mathematically (Ex. F-3, V R. 3631-3633).

In the first paragraph quoted above, Stone clearly showed that at the transmitter he would not put the spark gap in the vertical wire of the antenna circuit, as had Marconi's 1897 patent (see pp. 39-40, *supra*), but instead would put it in a separate oscillator or charging circuit adjusted to generate oscillations of the same frequency or wave length as that of the antenna circuit, and then transfer these oscillations to the antenna circuit. In his sketches he showed this transfer to be accomplished by a coupling transformer *t*.

Plaintiff attempts to construe the arrangement disclosed in the above letter as limited to "forced" oscillations, because of the phrase "I propose to impress," etc. Plaintiff argues that this letter consequently makes no disclosure of the transfer of oscillations through inductive coupling of resonant circuits, the method used by Marconi and the defendant (Pl. Brief, pp. 35-36). This argument, based upon a mere play on words, is untenable.[27] Any limitation of Stone's disclosure to

[27] If Stone had used the words "I propose to induce in the vertical wire," he might have limited his concept to transformer coupling, which was the specific mode of transfer shown by Tesla (see pp. 42-46, *supra*), and in Stone's diagrams, reproduced above. The use of the broader term "impress upon," to distinguish his method from the prior manner of generating the oscillations directly in the antenna circuit, indicates an intention to embrace generically the idea

"forced" oscillations is impossible in view of the context of the letter and more particularly the statements (1) that the oscillator circuit frequency would be made to correspond to the fundamental of the antenna circuit, (2) that the fundamental of the vertical aerial wire at the receiver should be the same as that of the aerial wire at the transmitter, and (3) that the several circuits would be tuned "one to another and all to the same frequency" (Ex. F-3; V R. 3631, 3633).

Since in the letter of June 30, 1899, Stone clearly disclosed, prior to Marconi, a transmitter having a charging or spark gap circuit and an antenna circuit coupled together by a transformer, a receiver having an antenna circuit and a detector circuit coupled together by a transformer, the two circuits at each station being tuned to one another, and all four circuits being tuned to the same frequency, this letter alone would be sufficient evidence to support the finding below (Finding LIV, LVIII; I R. 51, 57) that Stone anticipated this concept of Marconi's patent. But there is further supporting evidence.

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of transfer. That other than transformer coupling could be used is borne out by the fact that at the time of the letter Hertz's direct coupling was well known (p. 30, *supra*, and Lodge had already filed his application for patent showing such transfer accomplished by autotransformer coupling (see Lodge figs. 4 and 12, pp. 47 and 49, *supra*). See also I R. 762. Stone's careful choice of broad language was to be expected, for the letters to Baker were written for the purpose of making a record (I R. 739).

On July 18, 1899, Stone again wrote to Baker (Ex. G-3; V R. 3634), explaining and mathematically demonstrating how to achieve the "single" frequency. He pointed out that if the fundamental of the vertical wire (antenna) is of the same period (or frequency) as the oscillator circuit in the transmitter, the "*current*" in the vertical wire will be greater. Significantly, Stone himself observed in this letter that the tuning of the four circuits to the same frequency, which he had disclosed to Baker in the letter of June 30, "is practically the same as that employed by Tesla" (see pp. 42–46, *supra*), except that by the use of the large inductance coil *L* Stone "swamped" the reactions from the coil of the oscillating transformer. The "swamping inductance" *L* reduced the coupling between the open and closed circuits of the transmitter,[28] and

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[28] The letter of July 18, 1899, from Stone to Baker is in part as follows:

"The current in the vertical wire in my system may therefore be represented by a simple harmonic

$$A_2 \sin 2\,pt$$

and if the period of the impressed force be the same as that of the fundamental of the vertical wire then it may be represented by

$$A_1 \sin pt$$

"*The radiations will also be simple harmonic and of the same periodicity p* and will develop in the vertical wire at the receiving station a corresponding simple harmonic electromotive force *of periodicity p.*

"I space the coherer at the receiving station in a resonant circuit tuned to the periodicity p.

*　　　*　　　*　　　*　　　*

(Continued at bottom of p. 70.)

slowed down the transfer of energy from the plain gap charging circuit to the antenna circuit, thus permitting the former to oscillate more persistently.

These letters were acknowledged by Baker in a letter of July 22, 1899, to Stone, reading in part (Ex E-3; V R. 3629):

> The "selective" methods of space telegraphy therein described I believe I understand sufficiently to set up and operate them.
>
> Allow me to add that this speculation of the work which Marconi's experiments to date leave in rather primitive condition is

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"The first transmitting circuit shown in my letter to you of June 30 is practically the same as that employed by Tesla for the production of high frequency currents, except that I place an inductance coil *L* in the circuit to give additional means of tuning and to swamp by its greater inductance the reactions from the induction coil *t*, which would tend to make the oscillations multi-periodical instead of simple harmonic. The induction of this coil should be made large compared with the inductance of the primary of *t*.

* * * * *

"At the receiving station the coil *L* and condenser *k* form a resonant circuit which is attuned to the frequency of the current developed at the transmitting station.

"Again the inductance of the coil *L* should be made larger compared to the inductance of the secondary of the induction coil *T* at the receiving station in order to obtain well defined resonance to a single frequency."

The mode of operation of this "swamping inductance" to reduce the coupling between the circuits is explained in detail by defendant's expert Loftin at II R. 977, in connection with Ex. M-2, Loftin Sketch F; V R. 3590. See Brief for the United States in No. 373, this Term, pp. 20, 21, notes 19 and 20.

very important and should be prosecuted without delay by way of further development and protection by letters-patent.

Besides being the prior inventor in this respect, Stone showed diligence in adapting and perfecting his invention. He disclosed his invention to several persons in addition to Baker, and in January 1900 described the invention to his class at the Massachusetts Institute of Technology (I R. 760, 765, 1120, 1123). Further, during this and the succeeding period he was diligent in obtaining capital to form the Stone Wireless Syndicate (I R. 760) and in reducing the invention to actual practice (I R. 762), and he filed his application for patent on February 8, 1900, still prior to Marconi's earliest date (I R. 37). Thereafter, the Stone Telegraph & Telephone Company was organized in December 1901 (I R. 821), and it built wireless stations and sold apparatus, equipped a Navy collier and some battleships, and applied for a large number of patents (I R. 762–763, 822).

The character of apparatus used in the stations is described by Stone (I R. 766–767) as comprising, at both the transmitter and the receiver, resonant open and closed circuits loosely coupled inductively with each other, and all tuned to the same wave length in accordance with the Stone system as set forth in the Baker letters, the Stone patent No. 714,756, and the Stone M. I. T. lectures (I R. 765–766). All of these were prior to the earliest date established for the Marconi

invention, and although some of the stations built by the Stone Company continued up to 1909 or 1910 (I R. 822), the Company was never notified by plaintiff or Marconi that it infringed upon the Marconi patent in suit (I R. 774). What is of even greater significance, when the Stone patent was cited against Marconi's application in the Patent Office, Marconi acquiesced in Stone's priority, and purportedly limited his claims expressly or by inference to the use of the "variable inductances" in the *antenna* circuits, stated in his specification to be "essential elements" in his invention (see p. 28, *supra*).

(iii) *Summary*

Thus, in sum, the court below properly held that Stone anticipated Marconi's transmitter claims 1, 3, 6, 8, 11, and 12, because Stone, like Tesla, disclosed a charging circuit in the transmitter for causing oscillations of a desired frequency, and an antenna circuit coupled to the charging circuit through a transformer, and Stone disclosed the tuning of the two transmitter circuits to the same frequency.[29]

The court was equally corrected in holding that Stone anticipated Marconi's receiver claims here involved (claims 2, 13, 14, 17, 18, and 19) for

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[29] Indeed, as pointed out above (pp. 69-70), Stone further disclosed loose coupling of the two circuits in conjunction with the plain-gap persistently oscillating circuit which had been known to the art as such since 1894 (p. 35, *supra*, and footnote 32, p. 75, *infra*).

Stone disclosed loosely inductively coupled antenna and detector circuits in the receiver, both tuned to the frequency being received.

Similarly, the court was correct in holding that Stone anticipated the combined transmitter and receiver claims (claims 10 and 20). Claim 10 is the only claim requiring that the four circuits shall actually be in resonance with each other; it does not require tuning by a variable inductance and hence in any aspect is readable directly upon the Stone disclosure. Indeed, this claim was apparently inadvertently allowed in the Patent Office, as we shall show (n. 34, p. 76, *infra*). Claim 20, which also covered the transmitter and receiver, was likewise properly held anticipated by Stone, since if the four circuits are in electrical resonance with each other, then there must be means for bringing them into resonance. Stone disclosed such syntony for all four circuits, and justifiably left it to those skilled in the art to utilize any of the well-known means to achieve such synchronization.

The court's findings of fact as to anticipation by Stone thus sustain the ultimate findings of invalidity of Marconi's patent, and are adequately supported by the evidence.

(c) Marconi's "variable inductance" in the antenna circuit cannot save his patent

The only difference between Stone's disclosure and the claims of Marconi's transmitter group

was the use by Marconi of a "variable inductance" in the open antenna circuit to tune that circuit, in lieu of tuning it otherwise, as by adjusting the length of the antenna wire. This was the feature upon which the Marconi patent was allowed. We submit that this involved no novelty since it had already been disclosed in the earlier Lodge patent, and in any event was not a patentable invention.

The original Marconi application, filed November 10, 1900, was repeatedly rejected by the Patent Office examiners because of the prior art.[30] For example, a letter of rejection on June 3, 1902, held that the claims specifying a variable inductance were not patentable in view of Tesla and Lodge, and that an adjustable or variable condenser was not patentable over Tesla.[31] The ap-

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[30] For example, the Braun British patent No. 1862 of 1899 (Ex. Z 2, V R. 3626); Lodge patent No. 609,154 (p. 46, *supra*); Marconi patent No. 627,650 (p. 53, *supra*); and Tesla patent No. 645,576 (Ex. X 2, V R. 3662); cited by the Examiner V R. 3992, 3993, 4002. The Braun British patent and the corresponding Braun U. S. patent No. 797,544, granted August 15, 1905, upon original application filed February 6, 1899 (Ex. X 6, V R. 4066), disclosed a transmitter consisting of a separate charging circuit with spark gap and condensers, coupled to the antenna circuit by an oscillation transformer consisting of two inductance coils. These patents did not refer directly to tuning the circuits, but at that date the art was fully conversant with the fact that they should be, since Hertz, Lodge, Tesla, and Marconi (in No. 627,650) had fully appreciated and discussed its desirability.

[31] The examiner's letter of rejection, dated June 3, 1902, was as follows (Ex. X 5; V R. 4002):

"Claims 4, 13, 14, and 16, which specify a variable inductance and means for adjusting the inductance, are not pat-

plication was then abandoned and no action taken until October 6, 1903, when a petition to revive was filed, with an amendment containing all the claims here involved except claim 19 (V R. 4003). The examiner recommended that it be denied on account of the prior art, and the Commissioner denied it on December 2, 1903 (V R. 4040). Some months later, another petition for revival was presented (*id.* 4043) and was granted by the Commissioner on March 28, 1904 (*id.* 4066). The case was immediately referred to a new examiner, who on March 31, 1904—only three days later—allowed all but four of the rejected claims (*id.* 4068).

The sole basis for the allowance was that although the earlier Stone patent No. 714,756, like the Marconi application, showed a system in

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entable over Tesla because Lodge, of record, has shown that it is old to adjust the period of the circuit by a variable inductance; and claims 3 and 5, which specify an adjustable condenser, are not patentable over Tesla because applicant has shown in his prior patent 627,650, that this adjustment may be produced by a variable condenser. Since it is impossible to exactly calculate the values of the electro-magnetic constants of two circuits for the purpose of making their time periods agree, it is fair to assume that the electrical oscillator of Tesla must necessarily be made with an adjustable inductance or condenser, or both."

Particularly Tesla patents No. 645,576 and 649,621, Fessenden patents Nos. 706,735 and 706,736, Stone patents Nos. 714,756 and 714,831, and a paper presented by Pupin in December 1899 (V R. 4022). The examiner stated that Stone had disclosed "tuning a closed persistently oscillating circuit with the vertical transmitting wire as well as the advantages resulting therefrom," with the closed and open circuits "inductively connected" (V R. 4023).

which the circuits were in resonance with each other. Stone attained resonance (in the view of the new examiner) by adjusting the length of his aerial conductors, whereas Marconi attained the same result by including a variable inductance in the aerial circuit. The examiner accordingly allowed all claims which included that element (*id.* 4069). And the four remaining claims (claims 4, 5, 6, and 7) were held by the examiner to be allowable if amended by inserting a reference to a "variable inductance" in each claim (*id.* 4070).

The narrow ground upon which Marconi's application was allowed by the new examiner—that it included an inductance coil for tuning the aerial already shown by Stone—was clear error. For, as the former examiner had held, Lodge had already disclosed such an inductance coil, and had taught its use in precisely the same manner for tuning the same kind of aerial used by Stone.

Marconi's amended specification, and his patent as issued, represented the use of the variable inductance *a* and *a'* to be one of the "essential elements" required by his invention (Ex. X-5; V R. 3968; Ex. 21, IV R. 2591, lines 56-59).

Because of the examiner's reliance upon the variable inductance coil in the antenna circuit, his allowance of claim 10, the only claim in Marconi's patent which does not require tuning by a variable inductance, was apparently inadvertent, and doubtless attributable to the misleading statement in Marconi's amendment (Ex. X-5; V R. 4073) that the "claims now presented, all include an elevated conductor, or a circuit which is a good radiator of electrical waves, and means for adjusting the tune of such elevated conductor or radiating circuit."

This was the view of the court below in holding the Marconi patent anticipated, and its decision is fully sustained by the evidence.

Lodge in his patent No. 609,154 of August 16, 1898, had included a variable inductance in the antenna circuits at the transmitter and receiver for the purpose of tuning them (see pp. 46–53, *supra*). Marconi merely applied the function and mode of operation of Lodge's variable inductance without change to tune Stone's antenna circuit. Moreover, the use of Lodge's variable inductance in the antenna circuit, in lieu of tuning by adjusting the length of wire, had no practical effect upon the operation of the apparatus. The Stone system functioned in precisely the same way under either method, and no new result was accomplished. The combining of Lodge's feature with Stone's circuit was nothing more than the "skill of the calling," for to those skilled in the art, the variable inductance was plainly susceptible of, and indeed intended for, such use. Certainly, this exercise of ingenuity fell far below the level of invention.[55]

The court below therefore properly held that Stone in conjunction with Lodge anticipated the only feature of Marconi's transmitter which the

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[55] *Cf. Electric Cable Joint Co.* v. *Brooklyn-Edison Co., Inc.*, 292 U. S. 69; *Paramount Corp.* v. *Tri-Ergon Corp.*, 294 U. S. 464, 473; *Altoona Public Theaters, Inc.* v. *Tri-Ergon Corp.*, 294 U. S. 477, 486; *Toledo Pressed Steel Co.* v. *Standard Parts, Inc.*, 307 U. S. 350, 356.

Patent Office regarded as novel, and which was not anticipated by Stone alone.

4. *Prior litigation upholding Marconi patent No. 763,772 is distinguishable*

Plaintiff cites a prior decision of a British court holding the corresponding British patent valid, and two decisions in the lower federal courts favorable to the Marconi patent in suit. These constitute little authority on the question of validity in the case at hand, since in two of the decisions the Stone defense was not raised; and in the third Marconi's patent was held not infringed.

(a) Corresponding British Patent

Marconi v. British Radio Telegraph & Telephone Co., 27 T. L. R. 274, 28 R. P. C. 18 (Ex. 7; IV R. 2525), involved the Marconi British Patent No. 7777 of 1900 (Ex. 34; IV R. 2606). This patent, which claimed four-circuit tuning (IV R. 2614), was upheld as against the prior art by Mr. Justice Parker in the High Court of Justice (the case was not appealed). His decision, rendered on a record which contained no reference to the work of Stone, attributed all of Marconi's improvement to the radiation of prolonged oscillations from the transmitter by slowly feeding to the radiating or antenna circuit the energy of a closed, persistently oscillating charging circuit, by means of loose coupling between those circuits. But these features, as the court

below held, were previously disclosed in the United States by Stone; and since the work of Stone was not before Judge Parker in the English case, that decision is of no authority respecting the Stone defense. Indeed, far from aiding the plaintiff here, the English decision, as will be shown herein (pp. 81 *et seq.*), supports defendant's contention that its apparatus did not infringe Marconi's patent in suit.

(b) *Marconi Wireless Telegraph Co. of America v. National Electric Signaling Co.*, 213 Fed. 815

In the above captioned case, Judge Veeder in the Eastern District of New York held Marconi's United States patent here involved to be valid and infringed. The apparatus alleged to infringe consisted of a plain gap, persistently oscillating charging circuit, loosely coupled to the antenna circuit, as in the English case. Although the court recognized that "the broad claim of invention resides * * * in the independent adjustment of the capacity and self-induction of the four circuits, two at the transmitting station and two at the receiving station," the work of Stone was not referred to. Moreover, Judge Veeder virtually followed the reasoning in the British case (213 Fed. 848–849), and in his opinion the supposed novelty was found to inhere in features other than the tuning. For example, Judge Veeder stated:

> Marconi's improvement in his second patent, upon his own prior apparatus, and his solution of the difficulty involved in Lodge's compromise, consists in the substitution for a single circuit in both transmitter and receiver of a pair of circuits, one of which is so constructed as to radiate or absorb readily and the other to oscillate persistently and be a good conserver of energy * * * (p. 846).

For these two reasons, this case (which did not go to the circuit court of appeals) adds nothing persuasive to the British case, but like the British case, supports defendant's contention of non-infringement.

(c) *Marconi Wireless Telegraph Co. of America* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328, affirmed 265 Fed. 644

Judge Netterer in the Western District of Washington held the Marconi patent in question not infringed, mainly because it was construed in the light of the prior Stone invention to exclude quenched gap transmitters—the principal devices here charged to infringe. Although the district court entered a formal finding as to validity, that conclusion, in view of the decision as to noninfringement, is little more than *dictum* and would not be entered under more recent practice in like circumstances.* For while the Stone

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* *Electrical Fittings Co.* v. *The Thomas & Betts Co.*, 307 U. S. 241.

defense was before the court, it was relied on solely to sustain the defense of "noninfringement of the invention as limited by the prior art," and the circuit court of appeals in affirming the decision as to noninfringement expressly recognized Kilbourne & Clark's position in this respect (265 Fed. 646). The court's references to validity must therefore be treated as having been made *obiter*. Of even greater significance in depriving that case of any weight on the issue of validity is the fact recognized by the court below (I R. 97–99), that Judge Netterer did not consider the earlier Lodge patent No. 609,154 read together with the earlier Tesla patent No. 645,576, which was the alternative basis for the conclusion of invalidity below. Indeed, as regards the feature here involved, the *Kilbourne & Clark* case favors defendant's contentions, since Judge Netterer there specifically stated that tuned circuits and even four-circuit tuning were known prior to Marconi (265 Fed. 655, 661).

In the *Kilbourne & Clark* case, the apparatus alleged to infringe employed a quenched gap and tight coupling, and had no persistently oscillating charging circuit.[a] The district court described it as one which transfers the energy by a single

[a] These features were found to characterize defendant's transmitters in the present case, which are the principal apparatus alleged to infringe (Findings LXVIII, LXIX; I R. 4344).

impulse, as distinguished from other means (239 Fed. at 345):

> Such conversion is known to the art as impulse excitation. Impulse excitation of the oscillating currents is one in which the energy is set in motion within the oscillating, radiating circuit by a single impulse, as distinguished from a transfer of energy by other means.

This feature was held to distinguish the quenched gap transmitter of Kilbourne & Clark from Marconi's patented transmitter. After pointing out that the antenna circuit of Kilbourne & Clark's "impulse transmitter" was tuned to the desired frequency, and that the charging circuit (called "a disturbing circuit") had fixed elements of capacity and inductance, the court stated (p. 348):

> The difference in the operation of the defendant's impulse transmitter and the plaintiff's type of transmitter is in the fact that there is an entire absence of resonant tuning in the impulse transmitter, whereas in the tuned, coupling circuit transmitter, for any change in wave length there must be a change of tune of the two associated circuits, so as to keep them in resonance. The defendant's impulse transmitter is electrically the same as Lodge's and carries out his thought with relation to the transmission of energy.

The court's conclusion as to non-infringement because of differences in mode of operation was thus rested on the facts that Kilbourne & Clark used a high resistance spark gap which would rapidly cut off the charging circuit, damping further oscillations in that circuit but leaving the antenna circuit free to oscillate at its own natural frequency, and that the two circuits in the transmitter were neither loosely coupled nor required to be attuned to exact resonance with each other; whereas the essence of the Marconi system was the low resistance plain gap with its persistently oscillating circuit (i. e., reservoir circuit) loosely coupled to the antenna circuit and tied electrically to the antenna circuit for the entire period of persistent oscillation during which the energy is gradually transferred. This clear distinction in apparatus, producing a different mode of operation, lead inevitably to the court's conclusion of non-infringement. Because of this conclusion, the court held it unnecessary to enter into any detailed discussion of the validity of Marconi's patent.

It did, however, hold Kilbourne & Clark's apparatus to be identical with Lodge's transmitter [38] and, as to the feature of synchronization,

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[38] Judge Netterer stated: "The operation of Lodge patent, Fig. 4, is identical with defendant's in using impulse charging and variable inductance coil in the antenna. No reservoir circuit is used, and, when the radiating circuit is charged, it is entirely separated from the source of supply circuit which necessarily has some natural period" (239 Fed. 350).

it held that Marconi was not the first to invent tuned circuits nor even four circuits tuned to the same frequency (239 Fed. 328, 338–342).

Although the decree of non-infringement entered by the district court recited the validity of the Marconi patent, the Circuit Court of Appeals for the Ninth Circuit, affirming the decision below, noted that defendant's counsel "did not find it necessary to depend upon the validity of the Marconi patent for a defense" (265 Fed. 644, 646). This observation, coupled with the absence of any statements or reasoning in the district court's opinion as to validity, renders the recital of validity purely formal and in effect entered upon consent. Such a decree would scarcely be entered today, and is entitled to little weight. *Electrical Fittings Corp. v. The Thomas & Betts Co.*, 307 U. S. 241.

Hence, nothing in the *Kilbourne & Clark* case can serve as authority against the propriety of the decision below, in accepting the Stone (and Lodge) defense as a prior disclosure in anticipation of the Marconi patent. Indeed, upon the question of infringement the *Kilbourne & Clark* case is in accord with defendant's contention that its quenched gap, tightly coupled, transmitter apparatus did not infringe Marconi's patent, as will hereinafter appear.

Point II

MARCONI PATENT NO. 763,772, EVEN IF VALID, WAS NOT INFRINGED BY DEFENDANT'S APPARATUS

In the court below, the defendant urged at the close of the hearing that Marconi patent No. 763,772 had been proved not only invalid for anticipation, but also not infringed by defendant's apparatus.[39] The court below made evidentiary findings of fact which, we believe, would adequately support a conclusion of non-infringement, but held in its opinion that it was unnecessary to pass upon that defense because of the conclusion as to invalidity of the patent (I R. 94, 101). Since we consider that the defense of non-infringement is a sufficient ground to sustain the judgment in the Government's favor even if that court erred in its holding of invalidity, we reassert that defense before this Court. *Stelos Co.* v. *Hosiery Motor-Mend Corp.*, 295 U. S. 237.[40]

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[39] Record, C. Cls. No. 33,642; pp. 3883, 4133 *et seq.*

[40] Nothing in *Esnault-Pelterie* v. *United States*, 299 U. S. 201, precludes such a finding by this Court. It was there held that a judgment of the Court of Claims in a patent case could not be sustained in the absence of ultimate findings concerning either validity or infringement, and the case was remanded for such findings. Besides being distinguishable from the instant case—in which an ultimate finding of invalidity was made—the *Esnault-Pelterie* decision was rendered on certiorari to the Court of Claims under Section 3 (b) of the Act of February 13, 1925, which, before the amendment of May 22, 1939, permitted only "the findings of fact, the conclusions of law, and the judgment or decree" of the Court of Claims to be brought up. The amendment of

1. *Criteria available to test infringement*

In surveying the prior art to determine possible elements of novelty in Marconi's disclosure, the court below stated that Marconi in this case was attempting to claim the tuning of all four circuits as his improvement and as the feature infringed (I R. 31–38; p. 5, *supra*). The court then found that four-circuit tuning had been known and disclosed in the prior art by Stone, as well as by Tesla's patent taken with that of Lodge (Findings LVIII and LXII; I R. 57, 58). Hence, under the approach adopted below, there remained no feature of Marconi's asserted invention which could be used as a criterion to test the allegations of infringement. To obtain such a criterion we may look to the only decisions which have recognized and upheld any element of novelty in Marconi's patent—the decision of Judge Veeder in *Marconi Wireless Telegraph Co. of America* v. *National Electric Signaling Co.*, 213 Fed. 815 (E. D. N. Y.), and the decision of Judge Netterer in *Same* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328 (W. D. Wash.).

May 22, 1939 (c. 140, 53 Stat. 752), now permits the entire record in the Court of Claims to be reviewed in the Supreme Court on certiorari, as is true on certiorari to a circuit court of appeals under Section 240 (a) of the Judicial Code. The scope of review in patent matters coming from a circuit court—as did *Stelos Co.* v. *Hosiery Motor-Mend Corp.*, 295 U. S. 237—would therefore appear to apply to review of patent decisions of the Court of Claims under the 1939 amendment, when the evidence is brought up, as here.

affirmed 265 Fed. 644 (C. C. A. 9). We may also look to the decision of Justice Parker in respect to the corresponding British patent, *Marconi* v. *British Radio Telegraph & Telephone Co.*, 27 T. L. R. 274, 28 R. P. C. 18 (IV R. 2525). Even if these decisions be accepted as properly establishing invention in Marconi's patent over the prior art, the conclusion is inescapable that defendant's devices do not infringe.

Marconi's transmitter, to the extent held novel by these prior adjudications, involved the use of a persistently oscillating charging circuit, loosely coupled to the antenna circuit, and feeding only a small part of its energy thereto on each oscillation, so that the radiation in the antenna circuit for each discharge in the charging circuit would be prolonged, i. e., spread over a longer train of oscillations. Thus, Justice Parker in considering the Marconi British patent, found that from his transmitter Marconi desired to radiate a long train of waves of single frequency, as Lodge had wished to do; that instead of attempting suddenly to charge the antenna circuit by impulsive rush and then leave it to oscillate freely, as Lodge had done, Marconi proposed to feed it the energy to be radiated, a little at a time; that for this purpose Marconi proposed to use a charging circuit which was a persistent oscillator (i. e., a circuit of low resistance, shown as having a low-resistance plain spark gap, so that its oscil-

lations would not soon damp out) and to loosely couple this charging circuit to the antenna circuit so that only a small part of the energy of the charging circuit would be delivered to the antenna circuit on each oscillation, thus spreading the energy being radiated over a longer number of oscillations (i. e., lengthening the wave train) and at the same time avoiding the generation of a double frequency in the antenna circuit. The decision indicated that the entire improvement of Marconi's system flowed from the prolonging of the transmitted wave, which, when picked up by the antenna circuit of the receiver, thereby induced and then built up the amplitude of the oscillations in the coherer circuit (itself already a persistently oscillating circuit) and thus effectively actuated the receiver. Justice Parker attributed no novelty to the receiver,[6] and only incidentally adverted to the necessity of tuning the respective circuits to resonance, a requirement well understood by the prior art.

Judge Veeder in the *National Electric* case and Judge Netterer in the *Kilbourne & Clark* case made substantially the same analysis of the Marconi patent in suit. Tested by the features regarded as novel in these cases, the conclusion inevitably follows that defendant's apparatus did not infringe the Marconi patent in suit.

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[6] No claim of the British patent covered the receiver apart from the transmitter (IV R. 2613, 2614).

2. *Defendant's transmitters*

The transmitters here charged to infringe were of three types. By far the greater number were quenched gap transmitters (Finding XLVI; I R. 40). A few used the rotary gap (Finding XLIX; I R. 41), and only a very few early transmitters were of the plain gap type (Finding XLVI; I R. 41).

(a) Quenched Gap Transmitters

The quenched gap transmitters, comprising practically all of the defendant's transmitter types,[a] employed in their charging circuit a high-resistance "quenched gap" (instead of a low resistance plain gap) and relied on relatively tight coupling quickly to transfer the energy of the charging circuit to the antenna circuit in the relatively few oscillations permitted by the high resistance gap.[b] Because the charging circuit in-

[a] The Telefunken type (Ex. 79); Kilbourne & Clark type (Ex. 95); the type manufactured by the Navy (Ex. 93); Wireless Improvement type (Ex. 88); Simon type (Ex. 89); Lowenstein transmitter (Ex. 101); National Electric Supply type (Ex. 80); and Wireless Specialty type (Ex. 87).

[b] The "quenched gap" consists of a series of gaps or open spaces separated by cooling plates. The gaps are of high resistance, and the plates separating them offer large cooling surfaces, thereby tending to cool and extinguish the arc of current quickly. In the plain gap, on the contrary, there is only one gap or open space, and the terminals offer a minimum of cooling surface; hence the gap has low resistance, facilitating persistence of the spark. The conventional symbol for the quenched gap is a series of parallel lines of equal length, as G in Ex. 89.

cluded a high resistance gap tending to damp-out the oscillation quickly, and because the tight coupling enabled the charging circuit to part with its energy rapidly, it was not a persistent oscillator. The high resistance gap "quenched" the spark quickly, after but a few oscillations; the charging circuit then ceased to oscillate, after transferring the energy rapidly to the antenna circuit; and the antenna circuit then continued to oscillate at its own natural frequency. (Finding XLVIII; I R. 43.)

Further to aid in quickly suppressing the oscillation of the charging circuit, the frequency of that circuit was in practice preferably adjusted so that it would *not* be in tune with the antenna circuit.[66] With such detuning, after a few cycles

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[66] This detuning is explained by defendant's expert Loftin (II R. 991, 1031) and illustrated by him in Exhibit D-3. The *Electrician* article of November 10, 1911 (Ex. C-5, V R. 3392-3393) pointed out:

"To give the best result it is necessary that the reaction of the secondary circuit should assist the quenching in the primary, and for that reason the two circuits are slightly mistuned, namely, to the extent of about 2 percent. The closer the coupling the greater must be the mistuning."

Close coupling itself effects detuning and produces the "double hump" phenomena tending to prevent persistent oscillation of the charging circuit (see p. 26, n. 8, *supra*). Consequently, the instructions given by the Army Signal Corps to its personnel "that tuning of the closed and open circuits to resonance and the determination of the correct coupling between them are the two most important adjustments in a quenched gap transmitter," which plaintiff cites to distinguish defendant's quenched gap transmitters from those held not to infringe in the *Kilbourne & Clark* case (Pl. Brief,

of oscillation, the voltages of the two transformer coils (one in the charging and one in the antenna circuit) are in opposition with each other and hence stop the current flow in the charging circuit. Because the two circuits are thus coupled for only a brief instant, and because the quenched gap prevents persistence of oscillation in the charging circuit, the energy must be transferred rapidly from the charging circuit to the antenna circuit, which requires that the circuits be coupled tightly. It is true that during the extremely short time in which the current oscillation in the charging circuit continues, there is the generation of a double wave and diminution of efficiency which results from tight coupling and nonresonance, but these phenomena are only transitory. The close coupling is permissible and useful notwithstanding this minor fault because, when the charging circuit is cut off, its interference ceases, the antenna has received a much higher charge of energy than it would with the slow-feeding system of Marconi, the antenna is then free to oscillate at its own natural period, and it radiates a single frequency of greater initial amplitude (Ex. D-3, V R. 3628, II R. 991-998, 1031).

As was held in the *Kilbourne & Clark* case, *supra*, this principle was originally disclosed by

p. 43) are immaterial, for the "correct coupling" of defendant's apparatus, being tight, necessarily results in a detuning. Moreover, the apparatus does not employ the "persistent oscillator."

Lodge in 1898. In his patent No. 609,154, he employed a plurality of spark gaps, and his specification (p. 2, lines 57–85) described the manner of charging the aerial by "aerial disruption or impulsive rush," whereby the "charges so communicated are left to oscillate free from any disturbance due to maintained connection with the source of electricity" (see Fig. 4 of Lodge patent, p. 47, and n. 19, p. 48, *supra*). In 1906, Professor Wien in Germany redesigned Lodge's invention, devised a suitable spark gap apparatus having even more gaps than Lodge's system (since known as "quenched gap" apparatus) and arranged that the charging circuit and the antenna circuit should be out of tune during the charging process in order to aid quick extinguishment of the current flow in the gaps, thus cutting off the charging circuit from the antenna circuit as soon as possible.[9]

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[9] Professor J. A. Fleming, an expert associated with the Marconi Company (I R 554), in an article in *The Electrician* on June 11, 1909, explained and diagrammed the difference between the plain gap and the Telefunken quenched gap systems as follows (Ex. B 5; V R 897):

"The Telefunken discharger is based on the known fact that the damping of very short sparks is extremely large, and that if we can 'quench' or stop the primary oscillations after one or two swings the secondary circuit then continues to oscillate freely within a single period, as shown in Fig. 1. * * *

"Finally, as the whole of the energy transferred to the secondary circuit expends itself in the production of radia-

The substantial difference between Marconi's and the defendant's transmitters in arrangement, mode of operation, and result are thus apparent. Marconi's structure involves a *low-resistance plain spark gap* in the charging circuit, *loose-coupling* between antenna and charging circuits, and *exact tuning* of these circuits. This *decreases* the resistance of the charging circuit and renders it a *persistent oscillator*, a reservoir-like conserver of energy. Because the coupling is loose, it feeds to the antenna circuit, on each oscillation, only a little of its energy, thereby prolonging the trans-

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tion of one single wave length it must be more economical than methods which generate waves of two wave-lengths, but capture at the receiver radiation conveyed by only one of these wave-lengths."

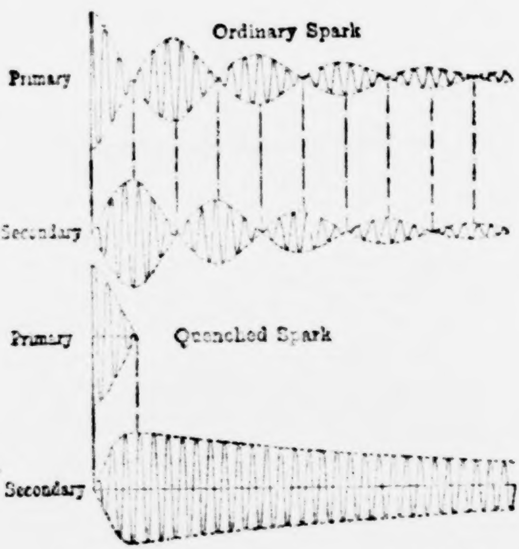

FIG. 1.—OSCILLATIONS IN INDUCTIVELY-COUPLED CIRCUITS.

mitted wave, but reducing its initial power. Marconi's charging circuit is thus electrically tied to the antenna circuit, as a driver, throughout its prolonged period of persistent oscillation, and does not leave the antenna circuit free to oscillate entirely by itself. The useful signal is transmitted *while* the persistent oscillation continues. (Ex. R–2, Loftin sketch J; V R. 3594, II R. 923–929.) [*]

The defendant's structures, on the contrary, involve a *high resistance quenched gap* in the charging circuit, *tight coupling* between the two transmitter circuits, and *detuning* of those circuits, thereby *increasing* the resistance of the charging circuit, preventing it from being a persistent oscillator, and providing for delivery of its energy to the antenna circuit "in a rush," after which it ceases to oscillate, leaving the antenna circuit free to oscillate at its own natural frequency. The useful signal is radiated *after* the charging circuit has delivered its energy to the antenna circuit and has ceased to oscillate. (Ex. D–3, Loftin sketch O; V R. 3628, II R. 991–998.)

The differences between Marconi's and the defendant's devices are tabulated, for convenient reference, in Table 1, following:

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[*] *Marconi v. British Radio Co.*, 27 T. L. R. 274, characterized Marconi's charging circuit as a reservoir feeding energy to the antenna in a manner similar to clock escapement mechanism.

Table 1

Marconi's transmitter	Defendant's quenched gap transmitters
STRUCTURE	
(1) *Low resistance*, plain spark gap in the charging circuit.	(1) *High resistance*, quenched gap in the charging circuit.
(2) *Loose* coupling between the charging and antenna circuits.	(2) *Tight* coupling between the charging and antenna circuits.
(3) *Exact tuning* of the two transmitter circuits.	(3) *Detuning* of the two transmitter circuits.
OPERATION	
(1) The low resistant gap *decreases the resistance* of the charging circuit, making it a persistent oscillator.	(1) The high resistant gap *increases* the resistance of the charging circuit, preventing it from being a persistent oscillator.
(2) The loose coupling feeds to the antenna circuit on each oscillation only a little of the energy, prolonging the transmitted wave but reducing its initial power.	(2) The tight coupling delivers to the antenna circuit on each oscillation a large part of the energy in a rush.
(3) The useful signal is transmitted from the antenna circuit while the persistent oscillation continues in the charging circuit.	(3) The useful signal is transmitted from the antenna circuit after the charging circuit has ceased to operate.
RESULT	
The transmitter transmits a prolonged series of oscillations not initially of very great strength but continually replenished by energy being delivered from the charging circuit so long as it persists in oscillation.	The transmitter transmits a series of oscillations of much greater initial strength and which die out at the natural rate of damping of the antenna circuit.

Contrary to Marconi's theory, the "impulsive rush" operation of defendant's transmitter results in a great increase in the efficiency of the quenched gap over the plain gap apparatus of the Marconi patent (II R. 1139), for there is no resonant retransfer of energy from the antenna circuit to the charging circuit after the antenna has been charged and commences to radiate at its natural frequency; and the transmitter's useful radiation has an initial amplitude or power much

greater than that obtained by slow feeding (*cf.* Ex. O-2, P-2, R-2, D-3; III R. 2120, 2291-2292).

Defendant's quenched gap apparatus is like that involved in *Marconi Wireless Telegraph Co. of America* v. *Kilbourne & Clark Mfg. Co.* (*supra*, pp. 80-84). This the Circuit Court of Appeals for the Ninth Circuit held did not infringe Marconi's patent because the quenched gap transmitters did not use the persistently oscillating charging circuit slowly feeding the energy to the antenna circuit, but instead followed Lodge's principle of charging the antenna quickly and then leaving it free to oscillate at its own natural frequency.

In summary: (1) The Lodge patent pointed the art along one path when it suggested that the antenna circuit be charged by "impulsive rush" to obtain in it an *initially strong oscillation*, and when it used a high resistance series of three or four spark gaps in the charging circuit to cause it quickly to stop oscillating and driving the antenna circuit, so that it would leave the antenna circuit free to oscillate at its own natural frequency and rate of damping. (2) Marconi pointed the art away from this principle, and in his system charged the antenna circuit only a little at a time, to obtain a *weaker but more prolonged series of oscillations* in the antenna circuit, using a single low resistance plain gap in the charging circuit to cause it to continue or

persist in oscillating and driving the antenna circuit during practically the entire period of radiation. (3) The Wien quenched gap systems employed by defendant returned to the path pointed out by Lodge, and travelled that path to a point still further removed from Marconi's principle than that at which Lodge had stopped, for Wien increased the number of gaps (to nine in the arrangement photographed at V R. 3906A for example), thus increasing their cumulative resistance, and also provided them with cooling flanges, all to extinguish the spark even more quickly. This produced still quicker cut-off of the charging circuit and still quicker stopping of any driving of the antenna circuit so as to leave the latter free to oscillate alone.

This difference in basic principle required differences in arrangements of apparatus. Marconi, in order to practice his slow feeding of energy during a large number of oscillations, required loose coupling and very exact tuning of the charging and antenna circuits to obtain a sufficient oscillation of the desired frequency in his antenna circuit. The quenched gap system, on the other hand, because it fed its energy in a rush and then allowed the antenna circuit to oscillate by itself, needed no such loose coupling or exact resonance, but preferred the opposite. In its preferred form, the two circuits were not only tightly coupled but intentionally de-tuned to further aid in

quickly stopping any prolonged driving of the antenna circuit by the charging circuit.

Since the prior art Lodge patent is the basis of the quenched gap system, Marconi's patent cannot embrace the latter without including and being invalidated by the Lodge disclosure.

That the quenched gap transmitter differs markedly from the plain gap type is further evidenced by the commercial displacement of the latter by the former, notwithstanding that the quenched gap transmitter went back to a principle antedating Marconi's patent. Soon after its introduction in this country in 1909, the quenched gap system displaced the plain gap "persistently oscillating" charging circuit of the patent in suit because its different mode of operation resulted in such greatly increased efficiency (II R. 1178). The Navy adopted the quenched gap and abandoned the plain gap apparatus in or about 1911 (II R. 1044). After 1911 the plaintiff's own United Wireless Company manufactured *quenched* gap transmitters exclusively, and because of the inability of the loose-coupled persistent oscillator to transmit beyond a short range (II R. 1044; III R. 2201) it abandoned the tuned circuit type (II R. 1181, 1210–1213) except at some existing stations (II R. 1269, 1270) and except for emergency use in war time.

Thus, upon the interpretation of the Marconi patent adopted by the courts in the few cases

which have considered and upheld it, upon principle, and in light of the prior art, defendant's quenched gap transmitters do not infringe. The differences in mode of operation and result requiring this conclusion are set forth in the evidentiary findings made below, which are supported by substantial evidence; and these evidentiary findings afford a sufficient foundation to uphold the judgment for defendant as to quenched gap transmitter systems on the ground of non-infringement.

(b) Rotary Gap Transmitters

A few of the transmitters alleged to infringe were of the rotary gap type, which consists of two widely spaced stationary electrodes and a rotating disc between them, having a number of spaced studs. The spark jumps from the stationary electrodes to the studs of the rotating disc when they are brought into alignment, and further rotation of the disc moves the studs away from the electrodes, lengthening the gap quickly and extinguishing the spark. As the court below held (Finding LXIX, I R. 44), this gap is similar to the quenched gap in that it effects a quenching of the spark as the moving electrodes recede from the stationary electrodes. Thus the rotary gap is simply another means for quickly quenching the spark and preventing the charging circuit from being a persistent oscillator. The finding of the quenching action of the rotary gap is not chal-

lenged by plaintiff; consequently the rotary gap transmitters must stand or fall with those containing the quenched gap, for they also employed the principles set forth by Lodge and avoided Marconi's system, as was urged below. The reasons urged above, to support the conclusion that quenched gap transmitters did not infringe, are equally applicable here.

(c) Plain Gap—Direct Coupled Transmitters

The few plain gap transmitters employed by defendant had the antenna circuit directly coupled across an inductance in the charging circuit, without any separate swamping inductances to loosen the coupling, as shown in the drawing in Finding XLVI, I R. 41. These transmitters thus did not embody the "essential" features of the Marconi patent, in which both loose coupling and persistent oscillation were required to attain Marconi's mode of operation and result. While in these plain gap transmitters the charging circuit had fewer gaps than that of Lodge, and hence would not cut off as quickly and efficiently, Lodge's mode of coupling the antenna and charging circuits to a common inductance (see illustration on p. 50, *supra*) was nevertheless common to these transmitters, and there is no evidence that they attained Marconi's slow feeding operation and result. For these reasons, as urged below, no infringement has been established in respect of the plain gap transmitters.

3. *Receivers*

We have shown above that the receivers charged to infringe the Marconi patent are so thoroughly grounded in the art prior to Marconi that if they infringe Marconi's receiver claims, those claims must necessarily be invalid for anticipation. The court below held these claims invalid, as it found no element in them not disclosed in the prior art. But if we turn to the other prior litigation on the patent, and on its British counterpart, we find that there is little basis even in them for any test of infringement of the receivers apart from the specific transmitters of Marconi.

In the prior litigation, no charge of infringement under the Marconi patent was brought or maintained against receivers except as parts of a system alleged to embody four-circuit tuning *and* the wave-prolonging loose coupled persistent oscillator at the transmitter. In the British case, Mr. Justice Parker indicated that the entire alleged improvement of Marconi's patent flowed from the supposed improvement of the transmitted wave (p. 78, *supra*), and Judges Veeder and Netterer followed substantially the same reasoning (pp. 79-84, *supra*). But, as we have already shown, these features are no part of the defendant's systems and, in any event, have no relevancy to the Marconi claims for receivers, *per se*. Hence even under the interpretation given Mar-

coni's patent by the courts which considered and upheld it, defendant's receivers are excluded from the valid scope of the patent. In any event, if any claim of the Marconi patent reads upon defendant's receivers, the identity of the prior art with such receivers is alone sufficient in our opinion to preclude any conclusion of infringement.[47]

PART TWO: FLEMING PATENT NO. 803,684

The court below found that Fleming patent No. 803,684, covering a use of a two-electrode vacuum tube, was not infringed, as charged, by defendants use of the three-electrode vacuum tubes in its receivers and transmitters, because the apparatus alleged to infringe was substantially different in structure, mode of operation and result from the device disclosed by Fleming. This decision is grounded upon adequate evidentiary findings of fact and upon substantial evidence. Moreover, apart from the question of infringement, the record and the findings of fact below would fully support the conclusion that the Fleming patent was invalid.

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[47] As pointed out (pp. 54-55, *supra*), Marconi's own prior patent No. 627,650 disclosed inductive coupling of two tuned circuits at the receiver, with the detector circuit tuned by a variable condenser, and the antenna circuit tuned in ways also known to the prior art and clearly tunable by a variable inductance as taught by Lodge. We have also shown (*supra*, pp. 42, 50, 56 *et seq.*) that Tesla, Stone, and others had taught that the two receiver circuits should be tuned and preferably loosely coupled.

The Fleming patent employed a two-element vacuum tube, and claimed its use as a rectifier to render capable of indication the high frequency alternating currents of wireless oscillations. The court below found as facts that the earliest date available to Fleming for his alleged invention was November 16, 1904; that prior to this date, the two-element device described by Fleming had been disclosed by Edison and was known to be a rectifier or detector of low-frequency alternating currents;* that use of a similar two-element vacuum tube rectifier as a detector of high-frequency waves was also known prior to Fleming's date; that the Fleming patent, if valid, was restricted to this particular use of the known Edison device to rectify the received alternating currents of radio signals in order to operate a direct current indicator in the received energy circuit, and that on principle, and in view of the prior art, Fleming's particular manner of using Edison's two-electrode rectifier was not embraced in the defendant's differently arranged and differently operating three-electrode vacuum tubes (Findings LXV, LXVI, LXX, LXXI, LXXII, LXXIII, LXXV–LXXX; I R. 62–74). The court below then found as an ultimate fact (I R. 117) that Fleming's claims in suit—claims 1 and 37—were not

* The court committed inconsequential error in impliedly limiting the prior art to use of the two-element rectifier with low frequencies. The prior art was not so limited, as we shall show (*infra*, p. 121 *et seq.*).

infringed by defendant's devices and entered judgment accordingly (I R. 75, 182).

The court below made no ultimate finding on the issue of validity, because as is not unusual it decided to rest its decision on the ground of non-infringement. However, for either ground, the prior art is an essential frame of reference. On the issue of infringement, it is used to determine distinguishing features of the plaintiff's patent in order to establish the criteria by which to gauge the alleged infringing use; on the issue of invalidity, the prior art is itself the test of whether the alleged invention was a patentable invention. In either case, therefore, evidentiary findings regarding the prior art and a comparison between it and plaintiff's alleged improvement are necessary; and such findings were made by the court below, together with findings as to the structure and operation of the devices. From these findings, the court below concluded there was no infringement, and we submit that this conclusion was clearly correct. But we further urge that, even were that holding improper, the same evidentiary findings would require an ultimate finding of invalidity, in that the device disclosed by Fleming, and its uses, were fully known to the art before Fleming's earliest date. Moreover, we shall show that apart from want of invention, Fleming's patent was void because of unreasonable delay in disclaiming, as the court below held

in its opinion, and for the additional reason that the subject matter of the disclaimer was improper. All these grounds were urged below by defendant, and although the judgment for defendant in respect of the Fleming patent was placed primarily upon absence of infringement, we reassert them as alternative and additional grounds for sustaining the judgment below." *Stelos Co. v. Hosiery Motor-Mend Corp.*, 295 U. S. 237.

Point III

THE FLEMING PATENT IS INVALID

1. *Disclosure of the Fleming Patent; Claims 1 and 37*

Patent No. 803,684, entitled "Instrument for Converting Alternating Electric Currents into Continuous Currents", was applied for on April 15, 1905 and granted on November 7, 1905 to plaintiff as assignee of Professor J. A. Fleming (Finding IV; I R. 8). Its specifications stated:

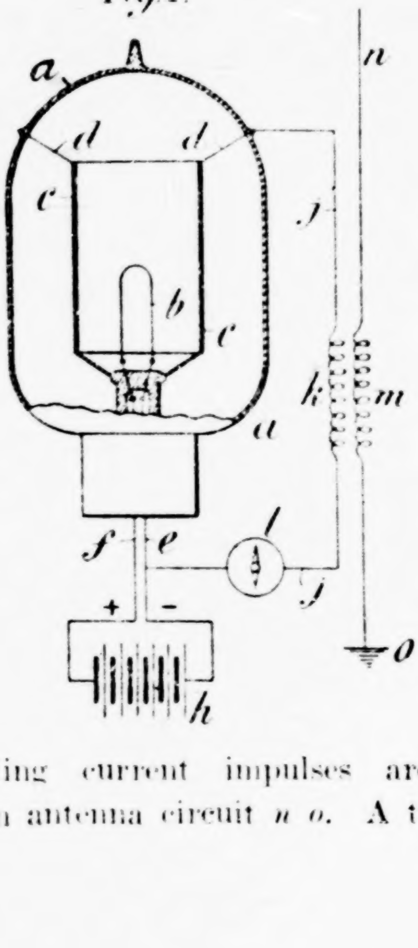
> This invention relates to certain new and useful devices for converting alternating electric currents, and especially high frequency alternating electric cur-

[a] Review of the art prior to Fleming is a necessary preliminary to a discussion of either infringement or validity. The latter issue, however, requires only a comparison between the prior art and Fleming's disclosures, while the issue of noninfringement calls for treatment of the alleged infringing structures as well. For convenience, we shall present our argument on invalidity after a review of the prior art, and follow with the discussion of noninfringement.

rents or electric oscillations, into continuous electric currents for the purpose of making them detectable by and measurable with ordinary direct-current instruments, such as a "mirror-galvanometer" of the usual type or any ordinary direct-current ammeter (Ex. 22; IV R. 2600, lines 11 *et seq.*).

Figure 1 of the patent illustrated the following apparatus to carry out the alleged invention (IV R. 2599):

Fig. 1.



Alternating current impulses are received through an antenna circuit *n o*. A transformer

m k couples the antenna circuit to a secondary circuit *c d j k j l e b*. In the latter circuit the element *b* is a carbon filament like that of an incandescent lamp (IV R. 2600, lines 85–86) and *c* is "a cylinder of aluminum open at the top and bottom, which surrounds but does not touch the filament" (*id.*, lines 87–90). The cylinder and the filament are enclosed in an evacuated vessel such as an ordinary lamp bulb *a*. The secondary coil *k* of the coupling transformer conducts the received alternating current to the cylinder *c* and the filament *b*. The indicating instrument or galvanometer *l* responds to the flow of current in this circuit.

The specification explained the operation of this device (IV R. 2601):

> The arrangement described above operates as an electric valve and permits negative electricity to flow from the hot carbon *b* to the metal cylinder *c*, but not in the reverse direction, so that the alternations induced in the coil *k* by the Hertzian waves received by the aerial wire *n* are rectified or transformed into a more or less continuous current capable of actuating the galvanometer *l* by which the signals can be read * * * (lines 18–27).
>
> * * * the aerial wire *n* may be replaced by any circuit in which there is an alternating electromotive force, whether of low frequency or of high frequency * * * (lines 30–34).

> Hence the device may be used for rectifying either high-frequency or low-frequency alternating currents of electrical oscillations * * * (lines 97–161).[30]

Only claims 1 and 37 of the patent are in suit, and read as follows (italicized letters refer to Figure 1):

> 1. The combination of a vacuous vessel (*a*), two conductors adjacent to but not touching each other in the vessel, (*b* and *c*), means for heating one of the conductors (*e. g.*, battery *h*), and a circuit (*j*) outside the vessel connecting the two conductors. (IV R. 2604, line 125.)
>
> 37. At a receiving-station in a system of wireless telegraphy employing electrical oscillations of high frequency a detector comprising a vacuous vessel (*a*), two conductors adjacent to but not touching each other in the vessel (*b* and *c*), means for heating one of the conductors (*e. g.*, battery *h*), a circuit (*j*) outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit (indicator *l*), and means for impressing upon the circuit the received oscillations (*e. g.*, transformer coil *k*). (IV R. 2604, line 125).

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[30] In Figure 2 of his patent, Fleming showed two of the vacuum tube rectifiers in reversed position so that current will flow through either one or the other of the valves during each half cycle of the alternation of current to provide two usable pulsating direct currents. This arrangement is not involved in the present suit, nor is the arrangement of three tubes in parallel, shown in Figure 3 of Fleming.

Both claims were thus identical in their structural elements: a vacuum tube containing two adjacent but noncontiguous elements or electrodes, connected by a circuit outside the tube, one element being heated. The claims differed only in that claim 37 included "means for detecting" the continuous or direct current in the circuit between the two elements (the indicator *l*) and "means for impressing upon the circuit the received oscillations" (transformer coil *k*). In the patent as originally issued, another difference had existed: claim 37 had specified that the tube was to be used "in a system of wireless telegraphy employing oscillations of high frequency" whereas claim 1 was applicable to any use of the claimed device, including use with low frequency. This distinction was, however, eliminated by disclaimer filed November 17, 1915, restricting the combination of the elements of claim 1 to use "in connection with high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission" (Ex. 22; IV R. 2505).[31] The result of the disclaimer was to limit both claims to use of the device for rectifying high frequency alternating waves or currents.

2. *The Art Prior to Fleming*

November 16, 1904, is conceded by plaintiff to be Fleming's earliest invention date for the patent

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[31] The specification was correspondingly amended by disclaiming all references to low frequency alternating currents (IV R. 2605).

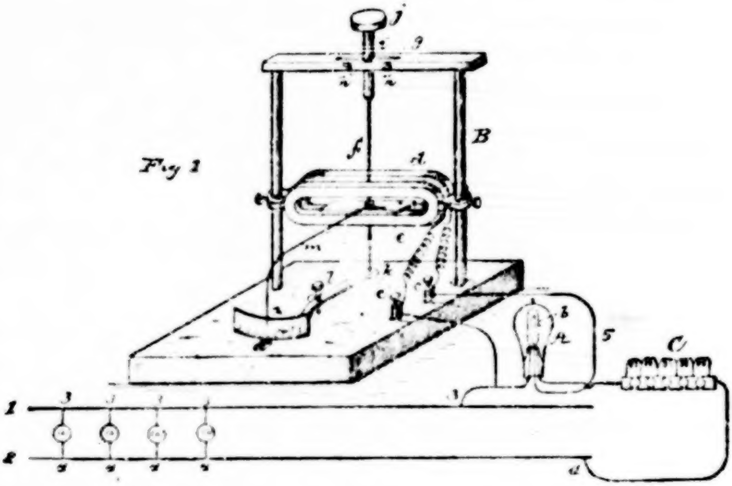
in suit (Finding LXVI, I R. 63). The art prior to that date begins with an invention of Thomas Alva Edison.

(a) The Edison Tube

Prior to 1884, the incandescent electric lamp as developed by Edison consisted of a vacuous glass tube or globe, containing a thin wire loop or filament, one end of which connected outside the globe to a resistance coil and thence to a generator, the other end being grounded outside the globe. The course of current through the filament in the partial vacuum caused it to become heated to incandescence. On October 21, 1884, Edison was granted United States patent No. 307,031, which announced:

> "I have discovered that if a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent electric lamp, and said conducting substance is connected outside of the lamp with one terminal, preferably the positive one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt-circuit thus formed, which shunt includes a portion of the vacuous space within the lamp. This current I have found to be proportional to the degree of incandescence of the conductor or candle power of the lamp. (Ex. J, IV R. 3297, lines 16–20).

Figure 1 of his patent showed this structure:



In this diagram, the filament circuit is wire *1*, *3* through filament *b*, resistance coils *C*, and wire *1* to the generator *2*. The "conducting substance" which is interposed "in the vacuous space within the globe" is the plate or electrode (unlettered) within the filament loop but not touching it, consisting of "a piece of platinum" (IV R. 3297, line 91). The "shunt-circuit" is from the plate electrode thence by wire *5* to contact *c* and coils *d* and *e* of a galvanometer *B*, then from the coil *e* of the galvanometer to contact *c'* and wire back to the filament circuit at *3*.

The description in the patent disclosed that (i) the vacuous space within the globe is a conductor of current between the plate electrode and the filamentary electrode, (ii) the strength of the current in the filament to plate circuit through the

vacuum within the globe depends upon the *temperature* of the filament, and (iii) the plate electrode is preferably connected to the *positive* side of the current supply. The claims of the patent are directed to the combination of the filament, plate and interconnecting circuit, including the galvanometer or indicating instrument. Claim 5, for example, is as follows:

> The combination, with an incandescent electric lamp, of a circuit having one terminal in the vacuous space within the globe of said lamp, and the other connected with one side of the lamp-circuit, and electrically controlled or operated apparatus in said circuit, substantially as set forth.

Structurally, the Fleming tube and its circuit as defined in the claims in suit are identical with those disclosed by Edison. Both have a vacuum globe containing two non-contiguous conductive elements, one susceptible of being heated, the other connected with the first by an outside circuit. Moreover, Fleming's claim 1 is patterned after the cited Edison claim 5, and structurally reads directly on the Edison disclosure.[1] Consequently the court below correctly held that these features of the Fleming patent cannot be treated as his discovery (Finding LXXII; I R. 67), and the plaintiff does not seriously dispute this.

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[1] See p. 108, *supra*.

(b) The Edison Tube as a Rectifier of Alternating Current

Edison disclosed that his two-electrode tube operated to pass current across the vacuous space within the tube between plate and filament. Fleming described the use of a substantially similar device to rectify alternating currents of Hertzian-wave frequency. But there was no novelty in such use, for it had been disclosed not only by others but by Fleming himself, years before the invention date of the patent here involved.

On January 9, 1890, more than ten years before he filed his application for that patent, Fleming acknowledged in a paper read before the Royal Society of London:

> It has been known for some time that if a platinum plate or wire is sealed through the glass bulb of an ordinary carbon filament incandescent lamp, this metallic plate being quite out of contact with the carbon conductor, a sensitive galvanometer connected between this insulated metal plate enclosed in the vacuum and the external *positive* electrode of the lamp indicates a current of some milliamperes passing through it when the lamp is set in action but the same instrument when connected between the *negative* electrode of the lamp and the insulated metal plate indicates no sensible current. This phenomenon in carbon incandescence lamps was first observed by Mr. Edison, in 1884, and further ex-

amined by Mr. W. H. Preece, in 1885. (Ex. I 1, IV R. 3413, 3414).

This 1890 paper further pointed out that the vacuous space is "unilateral" in its conductivity, that is, it permits current to flow from the hot carbon filament to the cooler metal plate "but not in the reverse direction" (IV R. 3415, 3417), and noted the ability of the tube to act as a rectifier of alternating current:

> When the lamp is actuated by an *alternating* current a *continuous* current is found flowing through a galvanometer, connected between the insulated plate and *either* terminal of the lamp. The direction of current through the galvanometer is such as to show that negative electricity is flowing from the plate through the galvanometer to the lamp terminal (IV R. 3416).

The then popular conception was that electricity flowed from the positive pole to the negative pole, but Edison's discovery made it necessary to revise this conception, and to accept the phenomenon of electricity's passing from negative pole to positive pole. Fleming's 1890 paper noted that it is *negative* electricity which is flowing from negative pole to positive pole, but emphasized that even this had been part of general *scientific* knowledge, as follows:

> The effect of heating the negative electrode in facilitating discharge through

vacuous spaces had previously been described by W. Hittorf ("Annalen der Physik und Chemie," Vol. 21, 1884, p. 90–139), and it is abundantly confirmed by the above experiments. We may say that a vacuous space bounded by two electrodes—one incandescent, and the other cold—possesses a unilateral conductivity for electric discharge when these electrodes are within a distance of the mean free path of projection of the molecules which the impressed electro-motive force can detach and send off from the hot negative electrode.

This unilateral conductivity of vacuous spaces having unequally heated electrodes has been examined by MM. Elster and Geitel (see "Wiedemann's Annalen," Vol. 38, 1889, Vol. 24, 1885, p. 83), who in experiments of various kinds have demonstrated that when an electric discharge across a vacuous space takes place from a carbon conductor to another electrode, the discharge takes place at lower electromotive force when the carbon conductor is the negative electrode and is rendered incandescent (IV R. 3421–3423).[5]

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[5] Other papers on the same subject published by Fleming years prior to November 1904, expounded and elaborated upon this phenomenon. Proceedings of Royal Institution of Great Britain, February 14, 1896 (Ex. J-1, IV R. 3425); London Electrician, February 21 and 28, 1896 (Ex. K-1, IV R. 3443; Ex. L-1, V R. 3447; Physical Society of London, March 27, 1896 (Ex. N-1, V R. 3466).

Fleming's reference in his 1890 papers to the unilateral conductivity of the vacuous space between filament and electrode, and the consequent ability of the tube to derive a continuous current from an alternating current, recognized the Edison tube to be a rectifier of alternating current in general terms; and this knowledge entered the public domain by publication.[9]

Rectification was the result of unilateral conductivity for the following reason: If to the tube with its external circuit from filament to plate, there be delivered an alternating current, the unilateral conductivity of the internal space between filament and plate would allow the flow of current between them only during those parts of the alternating current cycles when the alternating current is of such direction that the plate is rendered positive relative to the body of the filament. Thus the alternating current applied to the tube flows in the plate to filament circuit of the tube only as a pulsating continuous or direct current made up of alternate half cycles of the alternating current having a common direction of flow. Thus, the function known as rectification of the alternating current is performed.

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[9] It is fundamental in patent law that an inventor's own prior publication made more than two years (now one year) before his application for a patent is a bar to any claims of the patent applicable to the published disclosure. Rev. Stat. §§ 4886, 4920; 35 U. S. C. §§ 31, 69. *Wagner v. Meccano, Ltd.*, 246 Fed. 603 (C. C. A. 6); *Mailhahn v. RCA Victor Co.*, 89 F. (2) 317 (C. C. A. 4).

This mode of operation was a matter of general knowledge before the earliest date for Fleming's patent. It was specifically explained in a paper delivered by Fleming in 1896 (Ex. N-1, Experiment No. 27, V R. 3466, 3511). On February 17, 1897, at a meeting of the American Institute of Electrical Engineers in New York, Dr. Clark Howell described and illustrated the "Edison effect" in detail and mentioned that when the Edison tube was actuated by alternating current, unidirectional current resulted (Ex. M-1, V R. 3459, 3462); and in discussing Dr. Howell's paper, Dr. Kennelly specifically drew attention to this fact (V R. 3465).

In 1903, the deValbreuze patent, as we shall show, employed the two-electrode tube as a rectifier of alternating current (of Hertzian frequencies). And in October 1904, before the earliest date attributable to Fleming's patent, Wehnelt also disclosed the specific arrangement employed by Fleming, in which a source of alternating current was connected between the hot filament and cold electrode of a vacuum tube and was rectified by the unidirectional conductivity of the tube (Ex. O-1, P-1, V R. 3515). Indeed, Wehnelt improved the sensitivity of the Edison tube by substituting a better filament, capable of emitting a greatly increased flow of electrons.

Edison and Fleming employed carbon filaments in their vacuum tubes and heated the filament by

passing current through it. Since carbon is a poor electron emitter, and since the value of the current flowing between plate and filament depends upon a l[illegible]e electron flow from the filament, the current passing through the vacuous space in these tubes was not large, i. e., the sensitivity of the tube was small. The improvement in this respect, developed by Dr. Wehnelt and published in his paper of October 1904, consisted of a metal-oxide coating of the filament in Edison's two-electrode tube. Such oxide coating, when heated by the filament, emitted an enormously increased supply of electrons, greatly increasing the conductivity of the vacuous space.[28] In his article Wehnelt illustrated the application of the oxide-coated filament to a two-electrode tube and the use of the tube as a rectifier of alternating currents (Ex. O-1, translated in Ex. P-1; V R. 3515–3518). After describing the unidirectional conductivity of the tube in terms of the voltages necessary to force current through it between plate and filament, Wehnelt's article described the exact manner of connecting and rectifying the alternating current employed by Fleming (V R. 3516–3517), as follows:

Emission of Negative Ions by Incandescing Metallic Oxid. A glass tube *R* (Fig.

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[28] Wehnelt's paper in the *Annalen der Physik* set forth in great detail the results of numerous tests on filaments coated with oxides of the alkaline earth metals barium, calcium, and strontium, and showed the enormously increased emission obtained therefrom (Ex. Q-1, translated in Ex. R-1; referred to in Ex. P-1, V R. 3515).

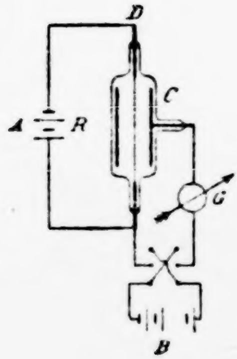

Fig. 1.

1), exhausted to a moderate extent, contains a brass cylinder C in the axis of which there is situated a thin platinum wire D covered with CaO. The wire can be heated to high temperatures by the current of two accumulators A. If I connect the wire D with the one pole, the cylinder C through a galvanometer G with the other pole, of a source of current B, then there only flows a current through the tube if D is connected with the negative pole of B. The experiment shows consequently that only negative ions are emitted from the incandescing oxid. * * *

Application of Discharge Tubes with Glowing Metal Oxid Cathodes in Practice. If in an exhausted discharge tube R (Fig. 4)[2] we push one or several metallic electrodes A close to the glowing metallic oxid electrode K (platinum sheet P covered with

[2] The cathode K is assumed to be turned 90° as regards the plane of the picture.

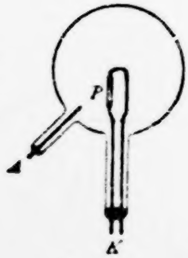

Fig. 4.

the CaO) then the discharge potential, if A is anode and K is cathode, amounts to only about twenty volts. If we reverse the direction of currents so that now A is cathode and K is anode, the discharge potential now amounts to some thousands of volts, since under deep pressures the cathode drop on metals takes on exceedingly high values. *If, therefore, we connect the electrodes* A *and* K *with an alternating source of current, the potential of which lies below the value which the cathode drop on the metallic electrode* A *has, then the tube acts as an ELECTRIC VALVE, in that it allows to pass through only one phase of the alternating current. The tube (Fig. 4) can consequently serve for the purpose of transforming alternating current into pulsating direct current.* [Italics supplied.]

It was therefore well known prior to Fleming, as was correctly held by the court below (Findings LXXI and LXXII; I R. 66–67), that the two-electrode vacuum tube shown by Edison

operated as a rectifier to receive alternating current and transform it into direct current.

(c) The Two-Electrode Vacuum Tube as a Wireless Detector

The knowledge in the prior art concerning the use of the uni-directional two-electrode tube to rectify alternating currents was not restricted to the rectification of low frequency current. Not only was its applicability to high frequency alternating currents a natural corollary of the tube's mode of operation with which the art was familiar; but its actual use to rectify high frequency currents for wireless detection[56] had been fully disclosed in the art antedating Fleming's patent.

To one skilled in the art, it was implicit in the earlier teachings concerning the Edison effect that the two-electrode tube would serve as a rectifying device of waves of wireless frequencies.

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[56] Many forms of detectors were known for detecting (or recognizing) that a signal has been received in a system of wireless telegraphy (see 1894 publication of Lodge, V R. 3876-3877). When the incoming signal energy was employed merely to "trigger" (i. e., close) a local battery circuit, as with the coherer (described at pp. 40-41, *supra*), the signal current could be employed without change, since the local battery supplied the pulsations of direct current for operating the indicator. When it was desired, however, to use the incoming signal current itself to actuate the indicator, the alternating current of the signal had to be rectified, i. e., converted into pulsations of direct current to which the indicator would respond, as was disclosed by de Valbreuze in 1903, for example (Ex. A-2, translated in Ex. B-2, V R. 3540-3547; Finding LXX, I R. 65-66).

None of the detailed treatises by Fleming, Howell, Kennelly and Wehnelt, discussing the rectifying action of the two-electrode tube, made any suggestion that this phenomena was dependent in any manner on the frequency of the alternating current. On the contrary, all treated it as applicable regardless of frequency (Ex. I-1, IV R. 3413; Ex. M-1; V R. 3459; Ex. P-1, V R. 3515). Indeed the work of J. J. Thompson, O. W. Richardson, and others in the years immediately prior to 1904, had identified the theory and operation of the Edison effect with the now familiar electron theory,[57] and had thus made obvious the potentialities of the two-electrode rectifier in the high-frequency field.[58] As the court below properly found, Thompson's and Richardson's experiments established that the incandescent filament of the Edison tube served to emit electrons, that the mass of these electrons was only 1/2000 of that of a hydrogen atom, and that their speed was so enormously high that the electron discharge device of Edison would operate practically without inertia.[59]

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[57] XLVI Philosophical Magazine (1898), 528 (Ex. S-1); XLVIII *Ibid.* (1899), 547 (Ex. T-1); V *Ibid.* (1903), 354, 429 (Ex. U-1, Z-1); IX Proceedings Cambridge Philosophical Society (1897), 244, 333 (Ex. X-1, Y-1); XI *Ibid.* (1901), 286 (Ex. V-1); XI Philosophical Transactions Royal Society (1903), 497 (Ex. W-1), I R. 680, 681.

[58] This is well explained by Miller, I R. 671.

[59] Because the electron is of infinitesimal weight, it requires only an infinitesimal interval of time to start and stop its flow, and the oscillatory period of even the highest frequency wireless wave is so extremely long, by comparison.

Consequently, it was to be expected that Edison's device would operate under both high and low frequencies in exactly the same way to pass the current in one direction between the filament and plate of the tube. As stated by the expert witness, Dr. Miller, in view of this knowledge in 1903 "any scientist at that date would have known it would so operate from his reading of the literature of the art. Indeed, he would have no reason to think otherwise" (I R. 678–684, at 682). That none in fact thought otherwise is clearly shown by the circumstances that despite exhaustive study of the phenomenon, no one suggested that the frequency would make any difference in the rectifying action of the device.[60]

But apart from these indications of the inherent efficacy of the Edison device as a rectifier of high frequency oscillations, which to the learned were unmistakable, there was specific disclosure by de Valbreuze of the application to wireless of the two-electrode vacuum tube. In his French patent No. 328,527 issued in 1903 (Ex. A–2, V R. 3540, translated in Ex. B–2, V R. 3547), de Valbreuze disclosed that the electronic vacuum tube would operate as a rectifier-detector of radio fre-

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that the electron flow will respond at once to such a wave and will even be regulated by minute fractions of a single high frequency cycle.

[60] Plaintiff itself, in demonstrating the Fleming device in the case of *Marconi Wireless Telegraph Company of America v. DeForest Radio Telegraph & Telephone Co.* 243 Fed. 551 (C. C. A. 2), used low frequency current (I R. 682).

quency currents, and he showed its use in the same circuit arrangement used by Wehnelt and by Fleming. The court below so found (Finding LXX, I R. 65–66), and the correctness of this finding is conceded by plaintiff (Pl. Brief, pp. 64–65). The text of the de Valbrueze patent read in part as follows:

> As receiver there is employed an apparatus which allows of re-transforming the alternating current into a continuous current, actuating a relay. For that recourse is had to apparatus called electric valves, placed as described hereinafter, and diagrammatically represented by Fig. 2. (V R. 3550).[91]

Claim 2 of the de Valbreuze patent repeaaed that his device would transform high frequency currents:

> The use of a device called an electric valve formed by a vacuum tube, or of several similar valves combined together, in order to transform into currents always in the same direction, the alternating currents of very rapid frequency transmitted to the receiving apparatus (V R. 3550).

And Figure 2 of the de Valbreuze patent showed two vacuum tubes K^1 and K^2 in reversed position,

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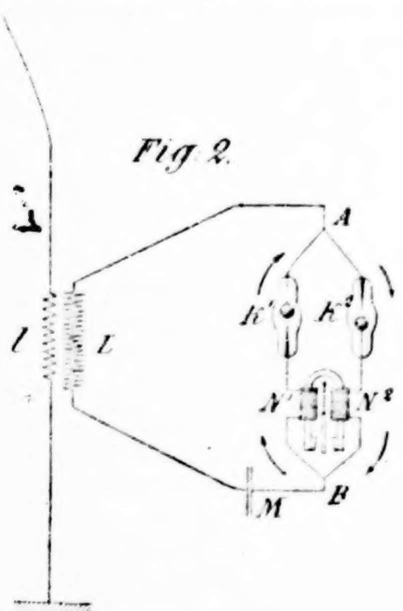
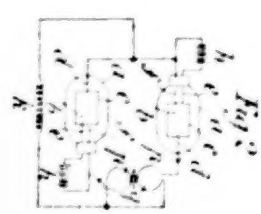
[91] Wehnelt also called his two-element tube an "electric valve" (see p. 120, *supra*), and so did Fleming in his specification (IV R. 2601, line 19, p. 107, *supra*). That is now a commonly used term to designate the two-element vacuum tube rectifier of the Edison-Wehnelt-de Valbreuze-Fleming type.

so that current would flow through one or the other of the valves during each half-cycle of the alternation of current.[62] The two half-wave rectifiers so connected operated as a full-wave rectifier, corresponding exactly to the two half-wave rectifiers shown by Fleming in Figure 2 of his patent. The identity of arrangement and operation is obvious from the following reproductions of Figure 2 of de Valbreuse and Figure 2 of the Fleming patent (the latter turned on its side to correspond with the orientation of the former):

de Valbreuse Patent *Fleming Patent*





[62] This was also known to Wehnelt. In his 1904 publication he stated: "By using the well known Graetz system of connection, both phases of the alternating current can be utilized" (Ex. O-1, translated in Ex. D-1; V R. 3518).

Thus prior to November 1904—Fleming's earliest date—it was well known that the rectifier vacuum tube called an electric valve would be suitable for use as a radio detector of high frequency waves, and it had been so applied by de Valbreuze.

The unidirectional operation of the vacuum tube of de Valbreuze, like that of Edison and Fleming, depends upon heating the cathode or filamentary element to cause the current of electrons to flow from it to the anode or plate. The cathode in the de Valbreuze tube, being a fine point, has a greater potential and current density on it than the large surface of his anode. Hence, in an alternating current circuit, it heats more and liberates more electrons than does the anode, and therefore exhibits the unilateral conductivity which makes it a rectifier. The only difference between the de Valbreuze vacuum tube and that of Edison and Fleming is that in the de Valbreuze tube the cathode was heated partly by electric current and partly by bombardment by the ions derived from the residual gas in the tube, whereas in the Edison and Fleming tube the cathode was heated practically entirely by current. But this involved no inventive difference. It was well understood by the art as early as 1896 that the heating of the cathode to cause unidirectional current flow could be accomplished in several ways. Fleming himself suggested that the cath-

ode of a two-electrode tube be heated by concentrating on it the rays of a lamp, which Professor Thompson characterized as equivalent to heating it electrically (Ex. X-1, V R. 3514),[93] Edison had already taught the art that the sensitiveness of the rectifier—i. e., the strength of the rectified current—would be increased if the temperature of the cathode were increased (see pp. 110-112, *supra*),[94] and Fleming, in his patented device, utilized the identical mode shown by Edison—the local battery circuit—to heat the cathode. This was not claimed, and obviously could not have been claimed, as the element of novelty in Fleming's patent.

3. *Fleming's alleged invention was not entitled to patent in view of the prior art*

In view of the state of the art at the time of Fleming's alleged invention (November 16, 1904), it is clear that plaintiff cannot assert a patentable right to any of the basic elements of Fleming's disclosed structure. Comparison between the essential features of the Fleming patent and the most pertinent prior art, as presented in

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[93] In addition to the modes of heating referred to, Wehnelt had used a speck of calcium oxide as his cathode and heated it by contact with an electrically heated member (Ex. O 1, translated in Ex. P 1, V R. 3515), and this is the mode employed in heating the cathode in practically all of the "heater type" or "unipotential cathode" tubes so widely used today.

[94] Fleming's 1890 papers acknowledged that Hittorf had also recognized this fact (see p. 115, *supra*).

TABLE 2

STRUCTURE

[illegible]	Fleming tube and Patent November 1904[1]	de Valbreuze, January 1903
(1) Electron-emitting filament heated by battery.	(1) Electron-emitting filament heated by battery.	(1) Electron-emitting fine point heated by concentration of current in fine point and by small confinement of tube.
(2) Cold plate.	(2) Cold plate.	(2) Cold spherical electrode or plate of large area, over which current is distributed widely so no heating occurs.
(3) Incoming alternating current connected in a circuit between plate (2) and filament (1); no limitation as to frequency of alternating current.	(3) Incoming alternating current connected in a circuit between plate (2) and filament (1); the alternating current to be of high or Hertzian wave frequency.	(3) Incoming alternating current connected in a circuit between plate (2) and fine point (1); the alternating current to be of high or Hertzian wave frequency.
(4) A galvanometer in the circuit to which the incoming alternating current is applied, which is operated by the one-way flow of the impressed alternating current permitted by the unidirectional conductivity of the tube.	(4) A galvanometer in the circuit to which the incoming alternating current is applied, which is operated by the one-way flow of the incoming alternating current permitted by the unidirectional conductivity of the tube.	(4) A galvanometer (N) or (N₁) or both in the circuit to which the incoming alternating current is applied, which is operated by the one-way flow of the incoming alternating current permitted by the unidirectional conductivity of the tube.

OPERATION

(1) The plate is alternately [illegible] positive and negative [illegible] by the impressed alternating current.	(1) The plate is alternately [illegible] positive and negative relative to the filament by the incoming alternating current.	(1) The plate is alternately made positive and negative relative to the fine point by the incoming alternating current.
(2) [illegible] alternating current of any frequency.	(2) [illegible] rapidly [illegible] by the [illegible] of high [illegible] wave frequency.	(2) [illegible] rapidly [illegible] of Hertzian wave frequency.

RESULT

The tube rectifies alternating current applied to its [illegible] so that [illegible] current can operate the galvanometer, revealing their amplitude in the process.	The tube rectifies alternating current applied to it [illegible] so these very currents can operate a galvanometer, revealing their amplitude in the process.	The tube rectifies alternating current applied to its [illegible] circuit so these very currents can operate a galvanometer, revealing their amplitude in the process.

[1] Fleming's device is placed in the middle column to facilitate comparison with the Edison, Wehnelt and the de Valbreuze disclosures separately or together.

tabular form in the accompanying Table 2, will disclose the virtual identity between Fleming's device and the prior art devices, in structure, operation, and result. Such comparison will similarly establish that claims 1 and 37 of the Fleming patent, even after the disclaimer, did not comply with the requirement of the patent laws that they specifically point out the particular contribution, if any, which the patentee made; and since these claims assert a right to more than Fleming was entitled to claim, they were invalid.[illegible]

It is apparent, therefore, that at the time of Fleming's alleged invention, the art was already conversant with the two-electrode vacuum tube of which the cathode electrode—the electron emitter—was heated in various ways to increase its emission of electrons. It was also known at that time that such a tube would have unilateral conductivity in the vacuous space between the electrodes, making it a rectifier of alternating current; that the tube would operate at high as well as at low frequencies; and that the two-electrode vacuum tube rectifier was useful as a detector in wireless apparatus. Fleming's use of the unidirectional conductivity of the Edison two-element tube to rectify incoming alternating current was consequently nothing more than the noninventive application of prior disclosures. And his use of

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[illegible] Cf. *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364, 372.

the current thus rectified to operate an indicator in the same circuit was precisely what Edison and Wehnelt had done earlier.

Plaintiff purports to distinguish Fleming's alleged invention from the Edison-Wehnelt rectifier arrangement on the ground that Fleming showed a use of his device with currents alternating at frequencies of the order of Hertzian waves. The vagueness and uncertainty of this differentiation was enough to condemn it;[65a] but in any event, such use is entirely without novelty, for the usefulness of the tube to rectify Hertzian waves was easily discernable and indeed squarely disclosed in the art. The two-electrode tube of Edison and Wehnelt was known to be a rectifier of alternating currents without regard to frequency, and by its very electronic character was capable of rectifying the entire range of alternating current frequencies, from the upper limit of Hertzian waves to frequencies corresponding to an occasional reversal of a battery current input. The use of a rectifier to detect wireless waves was old in the art, and deValbreuze had disclosed use of a two-electrode tube for this purpose. That the battery heated tube was a more sensitive rectifier than that of deValbreuze is without moment, for the Edison

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[65a] The Hertzian waves, as pointed out by Lodge (see pp. 36-37, *supra*), range from 186 cycles to 300,000,000 cycles; while audible frequencies range from 50 cycles to about 15,000 cycles. There is no dividing line between these frequencies, nor is either range sharply defined.

patent, Fleming in his 1890 papers, and many others had recognized that the sensitiveness of the two-electrode vacuum tube rectifier was improved by increasing the temperature of the cathode to full incandescence. And while the battery heated filamentary cathode of the Edison tube used by Fleming may have been a better electron emitter than deValbreuze's fine-point cathode heated by the Hertzian waves,[96] such battery heating of the filament to increase its emission was known prior to Fleming. Consequently, none of these features can be claimed as the novelty in Fleming's device, as the court below properly found (Finding LXXII; 1 R. 67).

Even if Fleming's claims in suit (p. 108, *supra*) were limited to battery-heating of the filament, instead of purporting to cover all means for heating it, at best he either (1) used the well-known alternating current rectifier shown by Edison or Wehnelt to rectify high-frequency alternating

[96] Fleming himself, in his patent, acknowledged that when strong Hertzian waves are received, their alternating current will itself be sufficient to heat the filament to incandescence. Since it is this same current which flows through and heats the fine point of the deValbreuze tube—which will be further heated by ionic bombardment—this filamentary point of deValbreuze will be heated at least as much as Fleming's filament under the same conditions. Fleming's claims in suit are not limited to battery heating of the filament but cover as well the acknowledged alternative in which the current of the received signal heats the filament; hence, these claims cover and are directly anticipated by the deValbreuze arrangement alone.

currents in circumstances not specifically shown by them, as found by the court below (Finding LXXIII, I R. 68), or (2) substituted the more sensitive rectifier of Edison or Wehnelt for the analogous rectifier of deValbreuze, who had already informed the art that such a device was desirable for the rectification of wireless waves. Whichever Fleming did, he produced no result which was not obvious (III R. 2149). Even if deValbreuze's disclosures could be disregarded, Fleming's contribution would amount to no more than a new use of an old device, as the court below found (Finding LXXIII; I R. 68), and since no new or unexpected operation was imparted to the Edison tube by using it to rectify high-frequency instead of low-frequency currents, the "new use" cannot support a patent monopoly. Fleming's structure may also be characterized as the result of varying the degree or extent of operation of a disclosed process or device, which this Court has held does not attain the dignity of invention. It was in fact to be expected from "observations of common experience" that once the feasibility was established of using the two-

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Smith v. *Nichols*, 21 Wall. 112; *Pennsylvania R. R. Co.* v. *Locomotive etc. Co.*, 110 U. S. 490, 498; *Electric Cable Joint Co.* v. *Brooklyn Edison Co.*, 292 U. S. 69; *Cuno Engineering Corp.* v. *Automatic Devices Corp.*, 314 U. S. 84.

Thompson Spot Welder Co. v. *Ford Motor Co.*, 265 U. S. 445, 451; *DeForest Radio Co.* v. *General Electric Co.*, 283 U. S. 664.

electrode tube to rectify alternating current, those familiar with the field "would seek to make use of known methods and appliances" to rectify wireless waves. (*cf. Concrete Appliances Co. v. Gomery*, 269 U. S. 177, 184); and once the rectifying properties of the two-element tube became known it was not long before the art sought to make use of the tube for alternating currents, such as wireless oscillations, as for example the two-electrode vacuum-tube rectifier which deValbreuze employed as a wireless detector in his patent.

Even the criterion utilized in cases of doubtful validity—the commercial success of the alleged invention—is not met by Fleming's device. The announcement of the Edison two-electrode tube excited world-wide interest, and scientists everywhere investigated it thoroughly (see pp. 113–122, *supra*), while the disclosure by Fleming of its use with high-frequency current evoked little comment. Measured by results and enduring use, comparison likewise favors Edison. The Fleming use was a fugitive one; a few were used experimentally in receiving stations, and later a number were sent to various Marconi receiving stations. But wherever they were installed, the sets were provided with crystal rectifier-detectors for alternate use (Finding LXVII, I R. 63), and within a year or two substantially all of the stations had discarded the Fleming tubes and were using crystals ex-

clusively (II R. 1374).[69] By contrast, the Edison tube-Wehnelt circuit is in large use today. Nearly every household A. C. radio set contains an Edison-Wehnelt rectifier operating to transform the low-frequency house lighting alternating current into direct current to operate or energize the tubes used for high-frequency uses.[70]

In summary, the evidentiary findings of the court below concerning the disclosures in the prior art of the entire substance of the Fleming

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[69] To argue that the deValbreuze diode was not sufficiently sensitive as a detector does not distinguish it from Fleming's disclosure, for his device was also insensitive. Even with the powerful Marconi interests behind it, the Fleming valve made no lasting impression on the art. It simply echoed deValbreuze's teaching that a rectifier was a desirable detector. The Fleming rectifier, like that of deValbreuze, passed from the scene in the face of the better rectifier-detector, the crystal. And all of them finally made way for the DeForest three electrode tube which, as a detector, substituted modulation amplifying relay action for rectification. The function of rectification in nearly every modern radio set is limited to conversion of the house lighting alternating current into direct current to operate the tubes; and this is performed by an Edison Wehnelt rectifier.

[70] As will be shown hereinafter (pp. 169-173), the decision in *Marconi Wireless Telegraph Co. of America v. DeForest Radio Telephone & Telegraph Co.*, 236 Fed. 942 (S. D. N. Y.), affirmed, 243 Fed. 551 (C. C. A. 2), is not entitled to any weight in the present case. Although holding that the Fleming patent here involved was valid and was infringed by DeForest's three-electrode tubes, for collateral reasons both parties had agreed in the district court and the circuit court of appeals that the two electrode and the three electrode device were essentially alike, thus eliminating any controversy on the point crucial to this case.

device are adequately sustained by the evidence, and would have justified an ultimate finding of invalidity for lack of invention. This Court may itself make such a finding as a basis for affirming the judgment below. Cf. *Stelos Co.* v. *Hosiery Motor Mend Co.*, 295 U. S. 237.

4. *The patent is invalid because of improper disclaimer*

There is no doubt that the Fleming patent, as issued on November 7, 1905, was partially invalid at least. For, as the court below correctly found (Finding LXXI, I R. 66-67), claim 1 of the patent, before the 1915 disclaimer, applied word for word to the earlier Edison patent and also read upon the arrangements disclosed in the 1890 and 1897 publications. Under settled law, such partial invalidity would defeat the entire patent unless the invalid portion were properly and seasonably disclaimed.[9] A disclaimer was filed in 1915, ten years after the patent issued, which the court below held constituted unreasonable delay invalidating both the disclaimer and the patent (I R. 106). This conclusion, which we believe was proper, is further sustainable upon the independent ground that the subject matter of the disclaimer was improper. Both grounds, which were urged by defendant in the court below, are

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[9] Revised Statutes, §§ 4917, 4922; 35 U. S. C. §§ 65, 71; *Ensten* v. *Simon, Ascher & Co.*, 282 U. S. 445, 452.

here advanced as additional grounds for affirmance of the judgment as to the Fleming patent. *Stelos v. Motor Meland Hosiery Corp.*, 295 U. S. 237.

(a) Unreasonable Delay in Disclaiming

For some ten years after its issuance, the Fleming patent was held out to the public as a monopoly covering its claimed features, including even Edison's device of a two-element electronic vacuum tube. Then on November 17, 1915, the plaintiff as assignee of Fleming filed a disclaimer in which it disclaimed the combinations of claim 1 and other claims—

> except as the same are used in connection with high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission.[illegible]

The invalidity of the disclaimer was urged by the defendant before the court below, and although the court made no findings of fact on the issue, it held in its opinion that there had been unreasonable delay in disclaiming. The court referred to Fleming's original claim of the use of the two-electrode tube to rectify both low and high frequencies, and said (I R. 106):

> In stating this feature in his patent specification as new and patentable, Fleming must have known that he was making a

[illegible] This disclaimer was filed at a time when plaintiff was about to sue a competitor (Pl. Brief, p. 70).

> claim that could not be sustained. There could have been no inadvertance in making this statement, and this matter alone would seem to be sufficient to render the Fleming patent invalid. True, he entered a disclaimer later, but the statutes which give relief where invention has been wrongfully claimed do so only on the condition that the inventor has not unreasonably neglected or delayed to enter the disclaimer. In the case at bar the disclaimer was not entered until eleven years after the patent had been taken out and long after other inventors had discovered other and different methods of making use of the Edison device without claiming to have invented it. We think that if ever there was a case of unreasonable delay in making the disclaimer it is presented in what is now before us and that the Fleming patent must be held invalid for that reason.

This holding is in full accord with both the record and the law. The record leaves no room for doubt that Fleming had full knowledge of Edison's work before he filed his patent application, for he had investigated it thoroughly (I R. 105-106). Yet he drew the specification for his patent to include Edison's vacuum tube whether used with current "of low frequency or of high frequency" (Ex. 22, IV R. 2601, lines 30-33) and stated that "the device may be used for rectifying either high frequency or low frequency

alternating currents of electrical oscillations" (*id.*, lines 97–102). His claim 1 was patterned closely upon Edison's claim 5, covering Edison's device without change (*cf. id.*, lines 125–129, with Ex. J., IV R. 3298, lines 50–54).

Since the record shows that Fleming's specification and claim 1 covered the Edison device and that Fleming had full knowledge of Edison's work, the court's conclusion that "there could have been no inadvertence" is well founded. *Cf. Ensten v. Simon, Ascher & Co.*, 282 U. S. 445. At any rate, in view of the conceded delay of more than ten years in filing a disclaimer—covering a period in which the electronic tube was developed—the court's conclusion that there had been unreasonable neglect cannot be said to lack substantial evidence.[illegible] The unreasonableness of the delay in the circumstances of this case is emphasized by the fact, as found below, that the three-electrode tube had been fully developed and adopted by the United States before the disclaimer was filed (Finding LXXXI, I R. 74).

(b) The subject matter of the disclaimer is improper

The impropriety of the subject matter of the disclaimer constitutes an additional and inde-

[illegible] The absence of findings of fact on the matter of delay is not fatal, in view of the alternative ground (anticipation) relied upon below for the conclusion of invalidity, *cf. Stelos v. Motor-Mend Hosiery Corp.*, 295 U. S. 237.

pendent ground to sustain the conclusion below as to its invalidity. This was urged below, but not passed upon because of the court's conclusion that "the patent is void in any event for failure to make disclaimer within a reasonable time" (I R. 107).

A disclaimer intended to save a patent from invalidity because of erroneous or excessive claims, "is usually and properly employed" to surrender a separate claim "or some other distinct and separable matter, which can be exscinded without mutilating or changing what is left standing." *Hailes* v. *Albany Stove Co.*, 123 U. S. 582, 587.[76] Since a disclaimer may not "change the character of the claimed invention" (*Milcor Steel Co.* v. *George A. Fuller Co.*, 316 U. S. 143 (1942)), and since every disclaimer "which does not surrender the whole claim, must add a new element" to it—which is not permissible—the surrender of a separable portion of the patent is an essential of a valid disclaimer. *Milcor Steel Co.* v. *George A.*

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[76] The essence of a valid disclaimer lies in "disclaiming a part separated in the patent itself" (*Strause Gas Iron Co.* v. *Crane Co.*, 235 Fed. 126 (C. C. A. 2); *Corn Products Refining Co.* v. *Penick & Ford*, 63 F. (2) 26, 30 (C. C. A. 7)), or a part "distinguishable on the face of the specification" (*Grasselli Chemical Co.* v. *National Aniline Co.*, 26 F. (2) 305, 310 (C. C. A. 2)), as opposed to something comprehended in the "general language" of the patent. *Strause Gas Iron Co.* v. *Crane Co.*, supra; *Albany Steam Trap Co.* v. *Worthington*, 79 Fed. 966 (C. C. A. 2); *Simplex Ry. Appliance Co.* v. *Pressed Steel Car Co.*, 189 Fed. 70 (C. C. A. 2).

Fuller Co., 122 F. (2d) 292 (C. C. A. 2), affirmed 316 U. S. 143.

Tested by these rules, plaintiff's disclaimer under the Fleming patent was invalid because it added[4] a new element thereto. The disclaimer made no change in the structure or mode of operation of the invention.[5] It sought only to change claim 1 to restrict the operation of the means already disclosed to high frequency current only instead of either high or low frequency current. The disclaimer thus added a new element, i. e., a source of high frequency alternating current, which before the disclaimer had expressly been treated as immaterial. The effect was the same as if the claim had been amended by adding a requirement not theretofore mentioned, such as "use of the disclosed structure in combination with a source of high-frequency current." This operated to "change the character of the claimed invention" and was therefore unauthorized by the disclaimer statute. *Milcor Steel Co. v. George A. Fuller Co.*, 316 U. S. 143.

It is submitted that upon the evidentiary findings below and upon the authorities here cited, an

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4 Compare cases upholding disclaimers changing the structural features of an invention, for example *Carnegie Steel Co. v. Cambria Iron Co.*, 185 U. S. 403.

5 Compare the attempted disclaimer of one chemical substance under a broad general claim covering a number of chemical substances, a form of disclaimer held void in *Grasselli Chemical Co. v. National Aniline Co.*, 26 F. (2d) 305 (C. C. A. 2).

ultimate finding of invalidity of the disclaimer is clearly justified because of the impropriety of its subject matter. The ineffectiveness of the disclaimer for either this reason or because of unreasonable delay in filing invalidates the Fleming patent.

Point IV

THE COURT BELOW PROPERLY HELD THE FLEMING PATENT NOT INFRINGED

The judgment below holding the Fleming patent not infringed applied to three types of three-electrode vacuum tubes which plaintiff charged as infringements: (1) the relay-detector, (2) the amplifier, and (3) the oscillator. After making detailed evidentiary findings as to the structure, mode of operation and result of Fleming's patented device and of the three-electrode tubes (triodes) used by the defendant, the court found as an ultimate fact that the triodes differed substantially from Fleming's tube in each of these essentials (Findings LXXV–LXXIX, I R. 69–73). We shall show that this conclusion is proper as to each type of triode used by defendant.

1. *The DeForest Three-Electrode Tube*

Prior to 1906, several vacuum tube devices were known to the art for use with wireless equipment. In the receiver, the Zehnder "Trigger Tube" was used (in which the received oscillations precipitated a discharge through the tube from an aux-

iliary battery) and the two-electrode tube of Edison-deValbreuze-Fleming was employed as a rectifier (V R. 3876-3877). In the transmitter, the Hewitt gas-filled tube was used as a generator of continuous waves, as had been disclosed by de Valbreuze (Ex. A-2, Fig. 1, V R. 3544, 3549). The only amplifier which had been proposed in the art prior to 1906 was the "negative resistance" characteristic of the gas-filled Hewitt tube which produced amplification but was unsatisfactory (Ex. O, IV R. 3320; Ex. P, IV R. 3323). All these tubes were of the two-element or diode variety.[7] In 1906, Dr. Lee DeForest invented the three-electrode tube and obtained United States patent No. 879,532 therefor on February 18, 1908 (Ex. K, IV R. 3299), upon application filed January 29, 1907.

This tube and its circuits differ in structure from the prior devices in having a third electrode known as a grid (consisting of a mesh or widely-spaced turns of wire) interposed between but not touching the filamentary cathode and the plate or anode, the grid being connected to the filament outside the tube by a circuit entirely independent of the plate circuit, and the incoming alternating current being connected in this independent grid circuit. The plate circuit of the tube is connected

[7] Except possibly the Zehnder Trigger Tube (V R. 3876, 3877).

permanently to the positive end of a high voltage (direct current) battery known as a *B* battery, while the filament of the tube is connected permanently to the negative end of that battery. The filament is heated to incandescence by current from a local battery circuit (the *A* battery). By this arrangement the potential of the plate is always kept positive relative to that of the filament, as in the original Edison circuit, so that the stream of electrons emitted by the hot (negatively charged) filament will be greatly attracted by the positively charged plate. As a result the local direct current derived from the *B* battery passes continuously through the filament-to-plate circuit.

The incoming alternating current signal is received in the grid circuit, and changes the voltage on the grid, according to the strength and characteristic of the signal, making the grid alternately more positive and more negative than its initial condition. When the grid is negative, it tends to repel or impede the flow of electrons from the adjacent filament; when the grid is positive, it tends to increase and accelerate the flow, but being placed closer to the filament than is the plate, the grid exerts a more powerful effect on the flow of electrons than does the plate, so that a negative charge on the nearby grid can counter-

act or diminish the effect on the electrons near the filament of a much higher positive charge on the more distant plate. However, since the area of the openings between the wires of the grid is much greater than the area presented by the grid wires themselves, most of the electron stream from the filament, when not repelled by a negative charge on the grid, passes through the openings in the grid and thence to the positive plate. It was thus De Forest's *discovery that a small change* in potential on the grid would produce, by relay action, a disproportionately large change of the direct current in the plate circuit, and the direct current in the filament-to-plate circuit, thus modified in proportion to the change of potential on the grid, would operate the indicator or detector in the plate circuit.

The ability of the relatively weak incoming signal potential on the grid to affect with proportionate variations the much more powerful current in the filament-to-plate circuit gives the tube its amplifying characteristic. The powerful *B* battery, which keeps the plate highly positively charged relative to the filament and can supply a large number of electrons to the filament to be emitted by it, provides a great deal of power for driving current through the plate circuit. As a

result the grid acts like a relay or throttle, whereby the small power input of the received oscillations controls the much greater power of the plate circuit. Since the output power in the plate circuit is much greater than, but faithfully controlled by, the lesser power in the input circuit, the input varied potential of the grid, operating the tube as a relay, is reproduced in facsimile, but much amplified, in the local current flowing in the plate circuit.

The amplifying powers of the triode of course operate equally well with high or low frequency variations of the grid potential. Moreover, the faculty of amplification enables the tube also to act as a self-sustaining generator of oscillations in a wireless transmitter. When so utilized, the triode's function is to generate a continuous oscillation which can be radiated by the antenna. The principle which enables it to generate oscillations may simply be stated. A small change in potential in the grid circuit will cause a much amplified change of current in the plate circuit. Hence, a small part of the plate current change may be utilized to create the grid voltage change necessary again to reproduce the plate current change, and this can go on indefinitely, so that the current in the plate circuit of the tube will maintain continuously an oscillatory variation. If a

sufficient part of the plate current is so used, it changes the potential on the grid sufficiently to reproduce in the plate current a larger variation, the "fed-back" part of which again produces a still larger variation of grid voltage. This action continues until a state of equilibrium is reached, with the plate circuit current oscillating continuously at its maximum value. That portion of the current in the plate circuit which is not being used to change the grid voltage may be applied to an antenna circuit, either directly or through a transformer, and will then be radiated from the antenna as a continuous Hertzian wave.

The same basic principle is employed with the De Forest tube when used in regenerative receivers, except that here the amount of plate current change used to change the potential of the grid is less than that necessary to reproduce the full change in the plate current. Because of this, the current change in the plate circuit dies out quickly unless an augmenting voltage is applied to the grid, as from an incoming signal. When such signal voltage is applied to the grid, a part of the amplified current change which it produces in the plate circuit is used to increase the voltage change on the grid, so that the plate current variation is rendered considerably stronger than if it were

effected only by the signal voltage on the grid. But as soon as the incoming signal ceases, the current variations in the plate circuit die out because the "feed-back" is insufficient to sustain them.

It was this three-electrode tube of DeForest, in the arrangements described above, which the defendant used, and which plaintiff charges constituted infringement of the Fleming patent; defendant used no two-electrode devices. (Finding LXVII; I R. 63).

2. *The differences between the triode and the diode are substantial*

The findings and conclusion of the court below, that the defendant's three-electrode tubes differed substantially from and hence did not infringe the Fleming device, are sustained not only by the general differences between the two structures in arrangement, operation and effect, but also by the efficacy of DeForest's device for purposes of which the Fleming tube were incapable—that is, amplification and oscillation.

(a) General Structure and Mode of Operation

The difference between Fleming's diode and the DeForest triode used by defendant is illustrated in the following comparative sketches made by

defendent's expert witness, Dr. Miller (Ex. I, IV R. 3283):

Fleming Tube and Circuit | *Defendant's Tube and Circuit*

MILLER DRAWING B

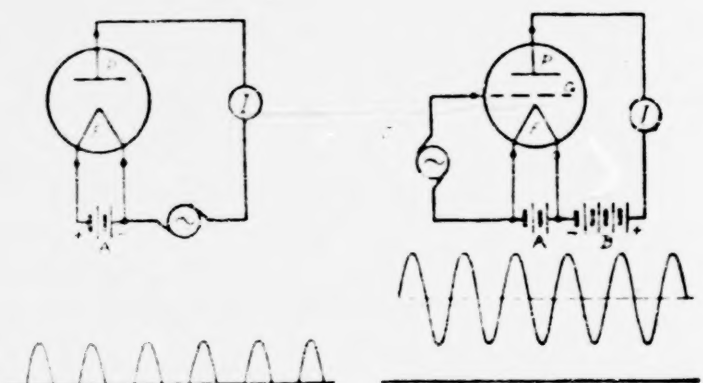


Fig. 1 | Fig. 2

The Fleming tube, as we have seen, consists solely of a heated filament and a cold plate, the plate circuit being connected to the *negative* side of the filament so that no steady component of current will flow in the filament-to-plate circuit. The antenna circuit receiving the incoming signal energy is inductively coupled to the plate circuit by a transformer. The incoming signal energy— a high frequency alternating current—is fed directly into the plate circuit by the transformer, alternately rendering the plate positive and negative relative to the filament, and permitting the

current to flow between filament and plate when the latter is positive but not otherwise. The result is a unidirectional flow of a portion of the incoming alternating current, which operates the galvanometer *I* or other signal indicating instrument. The only energy operating the galvanometer is the relatively feeble energy of the signal itself; that energy is in no way augmented. Moreover, since only one-half of the incoming alternating current is permitted to pass through the vacuous space of the tube and through the galvanometer, the actual operating energy is never greater than one-half of the original signal energy.

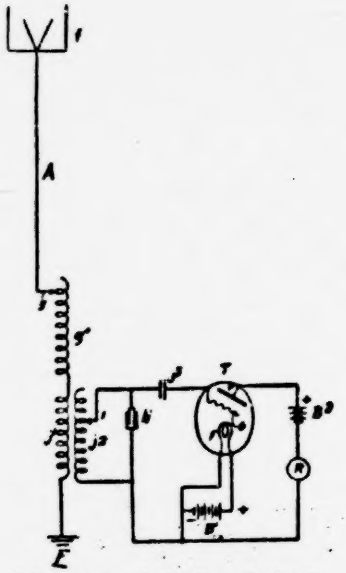
The DeForest three-electrode tube used by defendant, whether as detector, amplifier, or oscillator, comprises not only the two elements of the Edison tube used by Fleming but also a third element, the grid interposed between the filament and plate. The plate is connected permanently to the *positive* end of the local battery so that the electrons emitted by the hot filament will flow continuously to the positively charged plate. Since the plate remains positive, and is never rendered alternately positive and negative (as in Fleming's rectifying circuits), the tube tends *continuously* to pass a local direct current from the battery through the filament-to-plate circuit (which Fleming's tube did only half the time,

when the plate was positive relative to the filament). Being direct, this current does not require rectification. The input energy in the grid circuit is alternating current, but it is utilized solely to change the voltage of the grid, which regulates (by decreasing or increasing) the flow of the direct current from the battery. It is the flow of this locally produced direct current which operates the indicating device in the plate circuit, and not the incoming alternating current energy, as in Fleming's circuit; the DeForest tube uses the incoming energy only to impress different electrical potentials on the grid, thus accelerating or retarding the flow of the local continuous current.

These differences in arrangement, mode of operation and result between Fleming's and DeForest's tube are rendered even more acute when the DeForest device is used for particular purposes.

(b) The Three-Electrode Tube as a Detector

Defendant's three-electrode vacuum tube, when used in a detector circuit, is shown as follows (Ex. 83, I R. 70):



DeForest Audion, Used by Navy (Exhibit 83).

Fleming's tube, as we have shown, functioned solely as a rectifier of alternating current, as did Wehnelt's and Edison's in the circuits known in 1890. The defendant's tubes, however, had either no rectifying action whatever, or only an insignificant and unwanted rectification. There was in fact no need for rectification, since the current operating the indicator device (such as the earphones) was direct current from the local battery, and the incoming alternating current signal was used solely to vary the potential of the grid and thus correspondingly modulate the direct current of the plate circuit, to reproduce in it, by relay action, an amplified replica of the variation in grid potential.

Defendant used two forms of detectors: (1) one in which the desired negative voltage was maintained on the grid by a small battery, known as a *C* battery, and (2) one in which this function was performed by the incoming current passing through a condenser shunted by a very high resistance leakage path.[78]

In neither type is the incoming signal rectified to operate an indicator in the received current circuit, and in neither type does any rectification occur in the filament-to-plate circuit. In the first type (*C* battery-biased), no useful rectification occurs in any circuit. In the second type of detector (grid condenser-grid leak) such slight rectification as does occur is employed, not to operate an indicator, but merely to charge the grid condenser which takes the place of the *C* battery. In all forms of the three-electrode tube, the initial charge on the grid controls the local battery plate current (flowing as the electron stream), and determines whether the grid will give to that current, by relay action, a variation which is a true amplified replica of the incoming signal (as is desired in amplifiers and oscillators), or whether it will give it a variation which is an amplified

[78] The "grid leak" usually employed has a resistance of about 2,000,000 ohms, approximately the resistance of a pencil mark on a piece of paper.

replica of the *modulation* of the incoming signal, as is desired in a detector.

In the *C* battery detector, the grid is so initially charged by the *C* battery that it initially cuts down the plate current to a low value. Thus when it is alternately made more positive and more negative by the incoming signal, by its relay action on the electron stream, it alternately tends to allow large increases and to cause small decreases of the plate current from its initial value. These attempted variations of the plate current during the interval of a signal, when they are passed through a choking device (as a galvanometer, a telephone receiver or an iron-core transformer), are averaged up by such choking device. Such averaging of the large increases and small decreases in the current yields a net increase of current during the interval of a signal, such increase being proportional to the amplitude or strength of the signal. As the amplitude or strength of the signal is its intelligence carrying modulation,[*] the plate current, varied proportionally thereto, is made to *reproduce* the modulation of the signal in amplified form, by the relay action of the tube. The three-electrode detector thus *reproduces* the intelligence in the local battery current by modulation-

[*] In code transmission, the amplitude is raised to maximum for the duration of a dot or dash and dropped to a minimum value or zero at the end of a dot or dash. In the case of speech or modulated continuous wave transmission, the amplitude is intermediately varied at an audio-frequency.

amplifying relay action; it controls by relay action a new current which operates the indicator; it does not rectify the weak signal current to operate an indicator in the received signal circuit.

The "grid condenser-grid leak" detector has essentially the same mode of operation. Normally, an incoming wireless signal is carried by a continuous carrier wave of high frequency. When the wave arrives, the first few impulses charge the condenser with negative charges until a basic voltage is reached which is a balance between the average of the incoming pulses and the leakage through the high resistance which shunts the condenser. Thereafter, the basic voltage charge on the condenser and grid follows the average of the audio-modulation borne by the carrier wave. The grid, having a basic potential thus varied in accordance with the audio-modulation of the incoming signal, by relay action controls the electron stream as in the first type, except that its basic control is in this case the audio frequency variation of its potential produced by the grid leak and condenser. Hence, the average voltage on the grid, by relay action, varies the averaged value of the plate current to make it *reproduce* in its variations the modulation of the signal in amplified form (I R, 626–632).

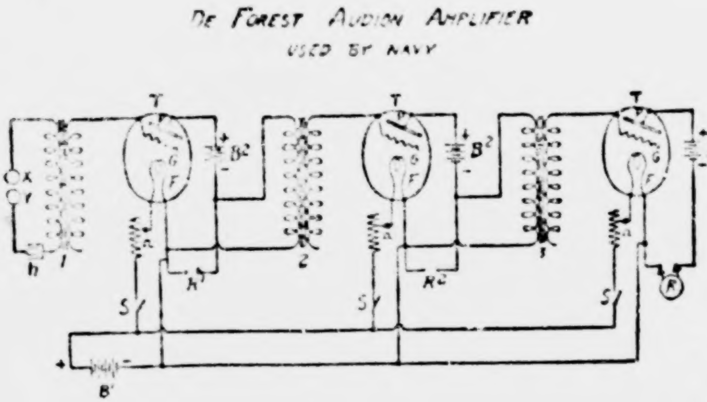
Even if there is theoretically some preliminary flow of signal energy to the grid condenser while it is charging, resulting in a slight rectification of the current before the condenser is charged to

its average potential, such flow is only temporary and in any event is not used to operate any indicator as in the Fleming device. The only indication of the signal in defendant's detectors is that of the averaged variation of the direct current in the plate circuit. The defendant's indicating device in the plate-to-filament circuit is operated solely by the large local energy, which usually is thousands of times greater than the incoming signal energy. Indeed, even if the signal energy (high frequency alternating current) could get over into the plate circuit, it could not operate the indicating device or have any effect upon it.

The triodes used in defendant's detectors served not as rectifiers, but as relay devices repeating, in the locally generated current in the plate circuit, amplified replicas of voltage changes produced on the grid by the incoming alternating current, suitably modified. In the first type above, the modification was obtained by use of a small local *C* battery in the grid circuit, giving it an initial negative charge. In the second type, it was obtained by employing the grid condenser and leak to cause the averaged grid potential to follow the audio modulation of the incoming signal. The court below therefore properly found that defendant's detectors differ from Fleming's in arrangement, operation and result (Findings LXXV, LXXVII, LXXIX, I R. 69-73).

(c) The Three-Electrode Tube as Amplifier

The three-electrode tubes used by defendant as amplifiers were audio frequency amplifiers. One example was the De Forest "Audion Amplifier" used by the Navy Department, and illustrated as follows (Ex. 85, I R. 72):



Another example of defendant's low frequency amplifiers is that used in the "T. P. S." set. The instrument shown above is a unit consisting of three *iron core* transformers to each of which is connected the input of an *amplifier* tube, all three tubes and their circuits being alike. The instrument was

> * * * of the three-stage type; each stage consisted of an iron-core transformer, 1, 2, 3, three-element audion T, battery B',

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Telegraphy through the earth's surface, as shown in the early Dolbear patent No. 350,299 (Ex. N 4, not reproduced) and by Preece (Ex. 123, not reproduced, and Ex. S-6, V R. 4103).

resistancer switch S, telephone R, and a filament lighting battery B′, which was common to all three stations. These elements were mounted in a wooden cabinet and the variable portions of the apparatus were operable on the outside. The terminals X Y were connected to the telephone binding posts or terminals of a receiver. The battery B′ was a separate piece of apparatus and connected to terminals on the amplifier. The amplifier element T was renewable. The circuit connections used are as shown in the diagram (Ex. D 2, not reproduced, see I R. 686).

In both types of defendant's amplifiers, however, the triode is connected to an audio-frequency circuit and is employed to amplify audio-frequency current, as is obvious from the arrangement and structure of the amplifiers. This meant that the incoming high frequency signal was either converted to, or reproduced as, an audio-frequency signal before it was fed to defendant's amplifiers. There is no evidence and plaintiff indeed does not contend that defendant ever used any of these tubes as radio frequency amplifiers; consequently, defendant's amplifiers

Defendant's amplifiers, when used in a radio receiver, were connected to the telephone terminals, i. e., in an audio-frequency circuit (I R. 635, 636), for the telephone must be in an audio-frequency circuit in order that an operator may hear the signal. *Iron* core transformers are useful only in low frequency circuits, *air* core transformers being used for high frequency circuits.

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are not within the language of Fleming's claim 37, which is limited to Hertzian waves of inaudible frequencies, nor within the language of claim 1, which by the disclaimer in 1915 was restricted to high frequency waves (see p. 109 *supra*).

Even if used with high-frequency currents, there would be no similarity between defendant's amplifiers and the Fleming patent, for in the amplifiers there is no rectification as in Fleming: there is only a direct current, the amount of which by relay action is made to vary in accordance with the variation of voltage on the grid, to *reproduce* in the plate current, a replica of the input signal.[8]

The difference between the Fleming two-electrode tube and defendant's three-electrode tubes operating in the amplifier circuit is illustrated in Dr. Miller's sketch shown at p. 148 *supra*. In the Fleming circuit the input energy is rectified, i. e., one-half of each wave cut off (see lower left-hand figure, p. 148, *supra*), each half wave starting from zero, rising to maximum and falling to zero. In the three-electrode amplifier, on the contrary, the current is not rectified in either the

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[8] The normal grid voltage is such that the tube will operate on the straight portion of the characteristic curve, whereby variation of grid voltage equally above and below the normal value will cause equal variation of plate current above and below the normal value. Generally, although not necessarily, a *C* battery is inserted in the grid circuit in order to hold the operation of the tube on the desired part of the characteristic (IV R. 3146-3148).

input or the output circuit. The change in voltage on the grid controls a wholly different circuit, i. e., the plate circuit, in which the direct current rises and decreases in amplitude in accordance with the voltage changes on the grid (p. 142, et seq. *supra*). As already stated, the input energy to defendant's amplifiers was invariably of audio-frequency. Had it been of high frequency, i. e., above the audible range, the output would be a variation of the amplitude of the plate current at the same high frequency, and this variation would be so rapid that nothing would be heard in the phones.

Thus, the defendant's amplifiers are not detectors and do not rectify. Their action is purely that of a relay, the grid voltage controlling the large local energy of the local *B* battery, to produce an *amplified* reproduction of the signal. This most important function and result of the triode amplifier is not attained and not possible in the Fleming device, as plaintiff in fact concedes in its brief (Pl. Brief 56–58). Since the devices function differently, infringement is not established even though there may be nominal or verbal similarity between plaintiff's patent and defendant's structure. *Westinghouse* v. *Boyden*, 170 U. S. 537.

The findings of the court below that the Fleming patent contains no disclosure of a device capable of amplifying (Finding LXXIV, 1 R. 68, 69) and that the three-electrode amplifier func-

tions in a radically different manner from that contemplated by Fleming (Finding LXXVI, I R. 72, 73), are thus clearly supported by the evidence.

(d) The Three-Electrode Tube as Oscillator

Defendant's three-electrode tubes, when used as "oscillators" in wireless transmitters, are typified by the General Electric No. 2, which is illustrated as follows (Ex. 116, IV R. 2792):

General Electric No. 2

The device, whose function is to send out a continuous wave, operates as follows: The grid and plate circuits are coupled by the coils d' d^2 so that any disturbance in either circuit is inductively communicated to the other. The path of the direct current in the plate circuit is from battery B' to the filament F, thence to plate P and back to battery. The alternating component

of this current is shunted from plate P through condenser c^2, coil d^2, wire 3, filament F to plate P.[82]

The alternating component of the large plate current, caused by the rise of current in the coil d^2, is communicated to the grid circuit by means of the shunt circuit, causing the grid circuit still further to increase the alternations in the plate circuit (by the amplifying action of the tube), until a state of equilibrium is attained in the plate and grid circuits, after which the alternations continue at a constant amplitude. These alternations are impressed on the antenna by the coupling transformer d' d^2 and are sent out as high frequency waves.

In this arrangement, the three-electrode tube operates as an oscillator producing a wave to be transmitted. The Fleming device, on the other hand, is a receiver only; it is in no sense a transmitter, could not function as a transmitter, and could not be used to send out a continuous wave.[83]

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[82] The condenser c^2 prevents the battery B^2 from short circuiting through coil d^2; and a choke coil (not shown) in the battery lead directly adjacent to the battery B^2 prevents the alternating component from flowing by way of the battery.

[83] Plaintiff's suggestion in the court below that the defendant's oscillator is a reversal of the Fleming or Edison valve is wholly unfounded, for there is no known way of reversing the Fleming device. It has only one circuit, and whether the current applied thereto is direct current or alternating current, the result is the same: current flows through the

Its sole function is to permit the measurement or indication of rectified high frequency current, and Fleming's patent so recites (V R. 2600, lines 25–30). It is overwhelmingly established that the two-electrode tube, with or without a battery, cannot cause oscillations, and plaintiff now concedes this (Pl. Brief 56, 58). Indeed, plaintiff asserts (*Id.* 57) that it—

> has never claimed that the Fleming patent describes amplification, oscillation or * * * use of gas or external field (to produce these effects), or that Fleming knew these things.

The plaintiff thus concurs in the finding of the court below in these respects (Findings LXXIV, LXXVI; I R. 68–70, 72–73). It urges, however, that because defendant's detectors, amplifiers, and oscillators use unidirectional conductivity, they in-

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device in one direction only. If the applied current is direct current, the flow will be continuous; if alternating current, the current flow in the circuit will be a series of pulsations of direct current. The same is true even if the circuit be split in two halves, as suggested by Waterman.

Nor is the three-electrode tube reversible in any sense. Indeed, one of its important characteristics is that it is unidirectional only, i. e., changes in the grid circuit are reflected in the independent current of the plate circuit, but changes in the plate circuit do not go back through the tube. Even when fed back by a feed back connection, the reproduction through the tube is still unidirectional. This feature was recognized by de Valbreuze, Wehnelt, Fleming, and others as a characteristic of the Edison and similar two-electrode tubes, years before the patent in suit was applied for.

fringe the Fleming patent. But as shown above (p. 110–127 *supra*), and as the court below properly found (Findings LXXI, LXXII; I R. 66–67), this feature was attributable to Edison and to the investigations which were published and became part of the public domain long before the application for the Fleming patent. Charges of infringement may not be based upon an element in a patented device which the prior art had disclosed. *United States v. Berdan Fire Arms Co.*, 156 U. S. 552. The court below correctly found, therefore, that the Fleming patent disclosed no device capable of oscillating (Finding LXXIV, I R. 68, 69) and that the three-electrode oscillators differ in arrangement, mode of operation, and result from anything contemplated in the Fleming patent (Finding LXXVIII, I R. 73).

3. *Commercial Success of the Three-Electrode Device*

The rapidity with which the triode replaced the older form of tubes, and its signal contributions to the art of communication, add to the evidence of its substantial dissimilarity to Fleming's diode. As the court below found, the great advancement of the art was attributable to the differences between the three-electrode tube and Fleming's tube, and not to matter contemplated in the Fleming patent (Findings LXXIV and LXXVII, I R. 68, 73). DeForest's device was in every sense a

true relay or amplifier, and by locating a telephone or other indicating device in the powerful local plate circuit and controlling it by the weaker input circuit, greater signal strength and fidelity of detection and reproduction resulted.

Few inventions since the telephone have wrought more revolutionary changes and established more new industries than has this new instrumentality. The three-electrode tube shortly after its invention was developed by the telephone companies into "a most successful speech amplifier or telephone relay" (I R. 710), and it is to the inertialess relay-amplification possible with this instrument that we owe our long distance telephone, and wireless broadcast transmitting stations and receivers, talking moving pictures, and public address systems. Dr. Eccles, an English scientist of high standing, wrote in 1919 that

> it is the three-electrode valve, and not the valve with two electrodes, that has been responsible for the overthrowing of the old methods and apparatus. That it has been a veritable revolution can be seen by comparing the common practice in wireless telegraphy of 1914 with that of 1919 (Ex. W, I R. 653).

Dr. Van Der Bijl, one of the highest wireless authorities in this country (Ex. L, IV R. 3304), agreed that

> the insertion of the grid into the valve resulted in a device of tremendous potentiali-

> ties—one that can justly be placed in the same category with such fundamental devices as the steam engine, the dynamo, and the telephone,

and added that

> the insertion of the grid has made the audion a device of immense practical importance and enabled it to perform functions that would otherwise have been impossible.

By way of summary, and to show more clearly the substantial differences between Fleming's and the defendant's tubes, we have prepared a table (Table 3) listing in parallel columns the distinctive criteria of infringement: of arrangement of parts, mode of operation and result, of the Fleming patent and of DeForest's three-electrode tubes. Comparison of these columns emphasizes the correctness of the finding below that defendant's device differed in arrangement, mode of operation and result from that of Fleming (Findings LXIX–LXXVII; I R. 64–73). The ultimate finding of noninfringement (Finding 1; I R. 117) necessarily follows from any one of these differences.[64]

[64] *Knapp* v. *Morse*, 150 U. S. 221; *American Fruit Growers, Inc.* v. *Brogdex Co.*, 283 U. S. 1.

Table 3

STRUCTURE

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(1) Electron-emitting filament heated by battery, or by input current.[1]	(1) Electron emitting filament heated by battery.[1]
(2) Cold plate.[1]	(2) Cold plate.[1]
(3) (absent)	(3) Interposed grid, connected in circuit to filament.
(4) (a) Incoming alternating current connected in a circuit between plate (2) and filament (1), the alternating current to be of high or Hertzian wave frequency.	(4) (a) (absent)
(b) (absent)	(b) Incoming alternating current connected in grid to filament circuit.
(5) (absent)	(5) High voltage local battery connected in the plate-to-filament circuit, with its positive end to plate and its negative end to filament.
(6) (absent)	(6) Means in the grid-to-filament circuit for controlling the initial negative charge on the grid relative to the filament, either a low voltage C battery connected in the grid circuit or a condenser bridged by a high resistance connected in the grid circuit.

[1] These two elements were in the prior art. See Table 2.

STRUCTURE—Continued

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(7) (a) A galvanometer in the circuit to which the incoming alternating current is applied, which is energized by the one-way flow of the incoming alternating current permitted by the unidirectional conductivity of the tube.	(7) (a) (absent).
(b) (absent).	(b) An indicator actuated by the fluctuation of the local battery current in the plate-to-filament circuit.

OPERATION

(1) The plate is alternately made positive and negative relative to the filament by the incoming alternating current.	(1) The plate remains positive relative to the filament at all times.
(2) (absent).	(2) The plate circuit current is derived from the high voltage local battery in the plate-to-filament circuit.
(3) The rectified alternating current in the single circuit of the device flows through and actuates the indicator.	(3) In the amplifiers, oscillators, and C battery-biased grid detectors, any minor unidirectional current existing in the grid-to-filament circuit, to which the incoming alternating current is applied, is simply waste.

OPERATION—Continued

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(4) Not so used in any circuit	(4) In the "grid condenser-grid leak" detector, the unidirectional current in the grid circuit is used to charge the grid condenser to give it a basic negative charge or bias relative to the filament. The basic static charge on the grid tends to become more negative when the amplitude of the received oscillation is greater, and less negative when the amplitude of the received oscillation is less, thus automatically following the audio-frequency variation in amplitude (modulation) of the oscillations, and causing those audio-frequency variations to be reflected in the plate circuit current.
(5) Limited by disclaimer to rectification of high (Hertzian wave) frequencies.	(5) All defendant's *amplifiers* act to *reproduce*, in the plate current variation, a substantial replica of the audio-oscillations introduced into the grid circuit, without rectification.

RESULT

(a) The Fleming device *rectifies* alternating input currents applied to its indicator circuit, and applies them to actuate a galvanometer in the same circuit, reducing their amplitude in the process.	(a) (absent).

RESULT—Continued

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(b) The Fleming device is not a relay and as disclosed cannot amplify or oscillate and does not *reproduce* anything in a new local current.	(b) The tube is a true *relay*, and an *amplifier*, and is capable of sustaining its own operation as an oscillation generator, without other elements acting within the tube envelope. As a detector, the tube is likewise a true relay and acts by "modulation-amplifying relay action" to *reproduce* in a new current in the plate circuit an amplified replica of the grid-received modulation.

4. *Plaintiff's favorable decision in 1916 against the DeForest three-electrode tube is not entitled to weight in this case*

Plaintiff relies upon *Marconi Wireless Telegraph Co. of America* v. *DeForest Radio Telephone & Telegraph Co.*, 236 Fed. 942 (S. D. N. Y.), affirmed 243 Fed. 55! (C. C. A. 2), which held the Fleming patent here involved to be valid and infringed by DeForest's three-electrode tubes. That decision, however, is entitled to little weight on either of these issues, for both parties had there agreed, for collateral reasons, that the two-electrode and three-electrode vacuum tubes were essentially alike, thus eliminating any controversy on the matter crucial to the decision here.

In the *DeForest* case, the plaintiff herein alleged infringement of the Fleming patent in

suit by DeForest's three-electrode tubes used as detectors by the DeForest Radio Telephone & Telegraph Company. The DeForest Company counterclaimed upon eight patents, six relating to two-electrode tubes, and two relating to the *three*-electrode tube. Marconi then confessed judgment as to infringement of both of DeForest's *three*-electrode patents (236 Fed. 942, 943; 243 Fed. 560, 561), and the case thereupon proceeded upon the Fleming patent here involved and the six remaining DeForest patents, all for *two*-electrode tubes. Both parties were actually using three-electrode tubes, and were suing on their respective two-electrode patents. Each was claiming that its own two-electrode patents were being infringed by the three-electrode devices of the other. Consequently, it was to the interest of both parties to have the court find substantial similarity between the patented two-electrode and the allegedly infringing three-electrode devices, and by the same token to have the court minimize the differences between the two types.[53] And both parties accordingly informed Judge Mayer of the district court that they considered the two-element and three-element tubes to operate on the

[53] The same observation applies to the minimizing, before Judge Mayer, of the difference between the *B* battery of the three-electrode circuit, which supplied the direct output current to the filament-to-plate circuit, and a mere sensitizing battery attached to the plate of the two-electrode tube, contributing no power to the output of the two-electrode tube.

same principle. The court quite naturally construed the prior art in the light of that concession, saying (236 Fed. 942, 953):

> In reading this literature it must be remembered that both sides agree that the DeForest two-element and three-element bulbs operate on the same principle.

The record in that case embodies no indication of the highly significant facts that by 1916 (the date of the decision) the Fleming valves had been discarded almost entirely as detectors in wireless communication apparatus, that ordinary crystals had been substituted in their place, and that the only vacuum tube in wide use was the three-electrode tube (Finding LXVIII, I R. 63). These circumstances render of little weight the district court's holding that the two-element device had brought into the art a "new, valuable, and easily obtainable detector which has gone into important commercial use."

The affirmance of the judgment by the circuit court of appeals is likewise deprived of weight by the parties' agreement and the inadequate record as to the desuetude of the two-electrode detector. The circuit court of appeals said (243 Fed. 561, 565):

> The detectors called by defendant "Marconi's earlier infringement" or the "two-electrode audion" are especially complained of, though since *it is agreed that the "two*

> *and three-electrode audions" operate on the same basic principle,* no reason appears why defendant must not contend that the same things which admittedly infringe the confessed patents also infringe all the counter-claim patents. [Italics supplied.]

In consequence of the fundamentally erroneous assumption on the part of the two Federal courts (premised upon the parties' agreement on the crucial issue: substantial similiarity of operation) and the courts' misconception of the commercial importance of Fleming's device, their opinions were properly accorded little value by the Court of Claims on the question of whether defendant's three-electrode detectors function in substantially the same way as Fleming's two-electrode tubes. And for like reasons, the decision is entitled to no more weight on the issue of validity. Since neither the district court nor the circuit court of appeals appreciated that the art prior to Fleming knew a rectifier would act as a detector, and that an electronic device that would rectify oscillations of low frequency would likewise rectify radio frequency waves, their contrary conclusions (243 Fed. 561. 563) can hardly be cited as authority in a case where these misconceptions do not exist.[86]

After the affirmance of its decision as to validity and infringement, the district court extended

[86] The finding of the Court of Claims with respect to the de Valbreuze patent alone (Finding LXX, pp. 64–66) discloses this misunderstanding in the *DeForest* case.

its decree to amplifiers and oscillators, on the theory that the Fleming valve was inherently capable of oscillating. 261 Fed. 393. This extension is in effect repudiated by plaintiff, for it now admits that "a simple diode cannot amplify, because it merely changes the form of the received currents" (Pl. Brief 56), while it concedes that the triode is both an amplifier and an oscillator (*id.* 57).[57]

CONCLUSION

For the foregoing reasons the judgment of the Court of Claims with respect to all claims except

[57] The devices called "amplifiers" in the *DeForest* opinion extending the decree were totally unlike the amplifiers in this case. The word "amplifier" was used to designate an assemblage of apparatus comprising two or more detectors, as Judge Mayer's opinion shows. Since the Government's amplifiers comprised no detectors, Judge Mayer's "amplifier" decision is in effect a holding that the defendant's amplifiers here do not infringe, for to find infringement he had to find that the DeForest "amplifiers" really were "detectors". Plaintiff's experts admitted in the record of the present case, and plaintiff now concedes (Pl. Brief 58), that amplification or oscillation was obtained in the demonstrations before Judge Mayer in the *DeForest case* "by gas inside the tube or by an electric field outside the tube", i. e., by converting the tube into a "negative resistance" device or by supplying the equivalent of DeForest's third electrode. In *Hewitt* v. *American Tel. and Tel. Co.*, 272 Fed. 194, Judge Mayer reversed his former viewpoint and held that the amplification obtained by gas characteristics (the manner in which the two-electrode valve was "demonstrated" before him in the *DeForest* case) is a wholly different thing from the relay amplification and oscillation attained by grid control, as in a three-electrode device.

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claim 16 of the Marconi patent No. 763,772, and with respect to the Fleming patent No. 803,684, should be affirmed.

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APPENDIX

The Act of June 25, 1910, c. 423, 36 Stat. 851 (35 U. S. C. § 68) provided:

> That whenever an invention described in and covered by a patent of the United States shall hereafter be used by the United States without license of the owner thereof or lawful right to use the same, such owner may recover reasonable compensation for such use by suit in the Court of Claims: * * * *Provided further,* That in any such suit the United States may avail itself of any and all defenses, general or special, which might be pleaded by a defendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise * * *.

This was amended by the Act of July 1, 1918, c. 114, 40 Stat. 704, to read as follows:

> That whenever an invention described in and covered by a patent of the United States shall hereafter be used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, such owner's remedy shall be by suit against the United States in the Court of Claims for the recovery of his reasonable and entire compensation for such use and manufacture: * * * *Provided further,* That in any such suit the United States may avail itself of any and all defenses, general or special, that might be pleaded by a de-

fendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise * * *.

Section 3 (b) of the Act of February 13, 1925, c. 229, 43 Stat. 936, 939, as amended by the Act of May 22, 1939, c. 140, 53 Stat. 752, 28 U. S. C. § 288 (b), provides:

> In any case in the Court of Claims, including those begun under section 180 of the Judicial Code, it shall be competent for the Supreme Court, upon the petition of either party, whether Government or claimant, to require, by certiorari, that the cause be certified to it for review and determination of all errors assigned, with the same power and authority, and with like effect, as if the cause had been brought there by appeal. In such event, the Court of Claims shall include in the papers certified by it the findings of fact, the conclusions of law, and the judgment or decree, as well as such other parts of the record as are material to the errors assigned, to be settled by the Court.
>
> The Court of Claims shall promulgate rules to govern the preparation of such record in accordance with the provisions of this section.
>
> In such cases the Supreme Court shall have authority to review, in addition to other questions of law, errors assigned to the effect that there is a lack of substantial evidence to sustain a finding of fact; that an ultimate finding or findings are not sustained by the findings of evidentiary or primary facts; or that there is a failure to make any finding of fact on a material issue.

Sections 4917 and 4922 of the Revised Statutes (35 U. S. C. §§ 65, 71) provide:

> SEC. 4917. Whenever, through inadvertence, accident, or mistake, and without any fraudulent or deceptive intention, a patentee has claimed more than that of which he was the original or first inventor or discoverer, his patents shall be valid for all that part which is truly and justly his own, provided the same is a material or substantial part of the thing patented; and any such patentee, his heirs or assigns, whether of the whole or any sectional interest therein, may, on payment of the fee required by law, make disclaimer of such parts of the thing patented as he shall not choose to claim or to hold by virtue of the patent or assignment, stating therein the extent of his interest in such patent. Such disclaimer shall be in writing, attested by one or more witnesses, and recorded in the Patent Office; and it shall thereafter be considered as part of the original specification to the extent of the interest possessed by the claimant and by those claiming under him after the record thereof. But no such disclaimer shall affect any action pending at the time of its being filed, except so far as may relate to the question of unreasonable neglect or delay in filing it.
>
> SEC. 4922. Whenever, through inadvertence, accident, or mistake, and without any willful default, or intent to defraud or mislead the public, a patentee has, in his specification, claimed to be the original and first inventor or discoverer of any material or substantial part of the thing patented, of which he was not the original and first inventor or discoverer, every such patentee,

his executors, administrators, and assigns, whether of the whole or any sectional interest in the patent, may maintain a suit at law or in equity, for the infringement of any part thereof, which was bona fide his own, if it is a material and substantial part of the thing patented, and definitely distinguishable from the parts claimed without right, notwithstanding the specifications may embrace more than that of which the patentee was the first inventor or discoverer. But in every such case in which a judgment or decree shall be rendered for the plaintiff, no costs shall be recovered unless the proper disclaimer has been entered at the Patent Office before the commencement of the suit. But no patentee shall be entitled to the benefits of this section if he has unreasonably neglected or delayed to enter a disclaimer.

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